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A Norlin Technology Company

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INSTRUCTION MANUAL

MODEL 836T

PRECISION OSCILLATOR

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A Norlin Technology Company

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INSTRUCTION MANUAL

MODEL 836T
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SPECIFICATIONS

Output Frequency:	150 Hz to 1200 Hz.
Output Voltage:	Proportional to frequency from 0.5 volts rms at 150 Hz to 5.0 volts rms at 1200 Hz into 1000 ohm load.
Volts/Hz Ratio:	Adjustable in accordance with Figure 2-3.
Frequency Control:	
Manual:	Variable in 0.01 Hz steps, 1.27 Hz per revolution of Manual Frequency Control.
Automatic:	Sweep-up or sweep-down between preset frequency limits at rates from 0.01 to 0.3 Hz/Sec.
Frequency Limit Presets:	Upper and Lower Limits of automatic sweep are presettable with four-digit thumb-wheel switches to any point within 150 Hz to 1200 Hz range.
Frequency Stability:	5 ppm/°C average temperature coefficient.
Frequency Display:	Five and one-half digit, LED display with resolution to 0.01 Hz.
Frequency Accuracy:	±0.005% of the maximum frequency.
Output:	Three phase, sine wave.
Phase Angle:	120 degrees ±2 degrees with Phase A lagging Phase C. 240 degrees ±2 degrees with Phase A lagging Phase B.
Harmonic Distortion:	Less than 2% THD.
Operating Temperature:	+2°C to +50°C.
Storage Temperature	-25°C to +85°C.
Storage Altitude	40,000 ft.
Remote Output:	TTL compatible signal provided to drive an appropriate customer furnished remote frequency indicator located up to 100 feet from oscillator.

(Continued)

SPECIFICATIONS (CONTINUED)

Front Panel Controls:	Upper and Lower Limit Preset Switches. Manual Frequency Control. Frequency Select (Manual/Automatic) Switch. Volts/Hz Trim Control. Frequency Preset Switch Power ON/OFF Switch. Rate (Hz/Sec).
Output Connector:	14 terminal barrier strip.
Power Requirements:	230 volts ±10%, 50 - 60 Hz, single phase.

SECTION I -- GENERAL DESCRIPTION

1.1 INTRODUCTION

This instruction manual contains information relative to the installation, operation, calibration and maintenance of California Instruments Model 836T Precision Oscillator. A detailed theory of operation is provided as an aid for maintenance personnel. A complete parts listing, schematic and component location diagrams are also supplied.

1.2 GENERAL DESCRIPTION

The California Instruments' 836T Oscillator provides a variable frequency, three phase output intended as a signal source for an Invertron power amplifier. The output frequency may be varied manually or automatically. In either mode, as the output frequency is varied, the output amplitude will vary, between preset limits, in direct proportion to the output frequency. It is powered from 230 volt, 50-60 Hz sources. The oscillator employs digital logic techniques for frequency generation. A crystal controlled oscillator serves as the reference for the digital logic circuits. This technique provides frequency stability of 0.005% which is not obtainable with analog circuits.

Frequency coverage of the Model 836T Precision Oscillator is 150 Hz to 1200 Hz accomplished in a single range. Frequency is adjustable in 0.01 Hz steps. Minimum and maximum frequency limits for the automatic mode are set, with two front panel thumbwheel controls, at any point within the 150 Hz to 1200 Hz frequency range. In the manual mode, the rate of frequency change is determined by operator rotation of the frequency control dial. In the automatic mode, the frequency is swept from one selected limit to the other (either up or down) at a rate determined by the rate switch setting, stopping at the frequency limit when it is reached. Rate of frequency sweep is variable from 0.01 Hz/sec to 0.3 Hz/sec in 0.01 Hz/sec steps with two thumbwheel switches. A five and one-half digit display shows the output frequency at any instant with 0.01 Hz resolution.

The crystal oscillator reference has an average frequency stability of five parts per million per degree Centigrade. Thus, with the frequency having been set at room temperature, the maximum variation would be approximately 125 parts per million (0.0125%) over the +0 to +50 degree Centigrade range. The oscillator frequency is scaled by digital logic circuits to the selected output frequency and then filtered to remove harmonic components.

The 836T Oscillator will shut down if the frequency is adjusted outside of factory set limits. This prevents selection of a frequency outside the operating limits of the associated power source.

The 836T Oscillator is equipped with a "soft start" feature that slowly increases the output amplitude from zero to the set level whenever the unit is first turned on. It also "soft starts" when resuming operation after automatic shutdown caused by selection of an out-of-limit frequency.

An electrically isolated output permits observation of the frequency at a remote point. An external 5 volt DC power source and frequency counter are required to enable this feature. Connection instructions are contained in Section II.

CAUTION

This equipment is powered by potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid touching the contacts of the power switch, fuse holder and transformer terminals. Also, avoid contact with the primary power circuits and output circuits of the associated Invertron if the oscillator is tested and/or adjusted with Invertron.

SECTION II -- INSTALLATION AND OPERATION

2.1 UNPACKING

Individual oscillators that are not assembled into a rack are shipped in cardboard containers with protective inner packing. Do not destroy this shipping container until the unit has been inspected for possible damage in shipment.

2.2 POWER REQUIREMENTS

The California Instruments 836 Precision Oscillator operates from 230 volts, 50 - 60 Hz and requires less than 1/2 ampere.

2.3 FUSE REQUIREMENTS

A single 1/2 ampere, 250 volt, type 3AG fuse is installed in series with the 230 volt AC line. It is housed in a "twist out" fuse holder mounted on the rear panel.

CAUTION

Replace this fuse only with one having the same ratings.

2.4 EXTERNAL FREQUENCY MONITOR CONNECTIONS

The external frequency monitor requires an external 5 volt DC power supply and frequency counter. Either may be located as far as 100 feet from the oscillator. Connections are made as shown in Figure 2-1. There are no adjustments or operational procedures relative to the monitor.

2.5 ACCEPTANCE TEST PROCEDURE

Inspect the unit for possible shipping damage immediately on receipt. If damage is evident, notify carrier. DO NOT return the instrument to the factory without prior approval. If the unit appears to be in good condition, verify that the POWER switch is in the OFF position and then connect the power cord to a 230 volts, 50 - 60 Hz receptacle and perform the tests of paragraphs 2.5.1 through 2.5.6. Detailed test procedures are provided in Section IV of this manual. They should be consulted if, as a result of performing these tests, further evaluation of the oscillator is required.

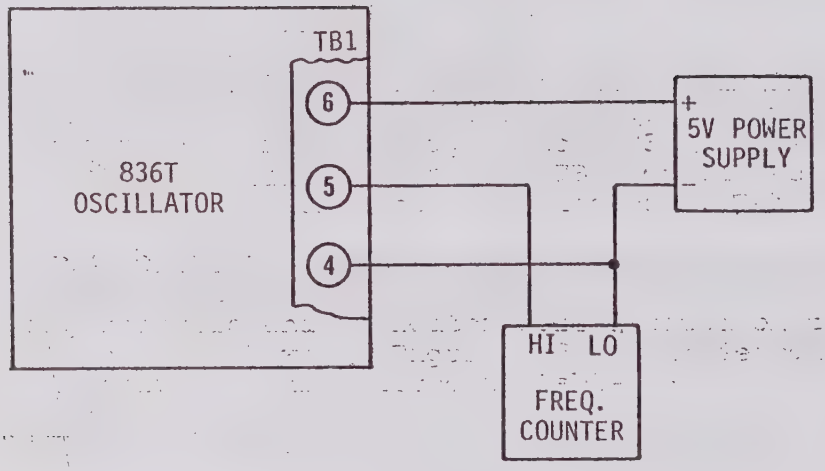

Figure 2-1. External Frequency Monitor Connections.

2.5.1 PRELIMINARY CONTROL SETTINGS

1. POWER switch OFF.
2. VOLTS/HZ control at midrange.
3. FREQ SEL switch in MAN position.
4. UP/DN switch in DN position.
5. UPPER LIMIT switches at 1200 Hz.
6. LOWER LIMIT switches at 0150 Hz.
7. Connect an oscilloscope and a frequecy counter to TB1 (on rear panel) between terminals 9 (ground) and 10.

2.5.2 FREQUENCY PRESET AND RANGE

1. Place the POWER switch in its ON position. Verify that the displayed frequency is the same as the UPPER LIMIT switch setting (1200 Hz). Also, verify 1200 Hz on the counter.

2. Place the UP/DN switch in the UP position and actuate the PRESET switch (press either up or down). Verify that the displayed frequency is the same as the LOWER limit switch setting (150 Hz). Also, verify 150 Hz on the counter.

2.5.3 MANUAL FREQUENCY CONTROL AND RANGE LIMIT

1. Rotate MANUAL FREQUENCY control counterclockwise. The frequency should decrease and the display should begin to blink before the frequency is decreased to 140 Hz. A blinking display indicates that the displayed frequency is outside the factory set limits. Verify that an output is not displayed on the oscilloscope when the display is blinking.

2. Rotate MANUAL FREQUENCY control clockwise until 150 Hz is displayed. Verify that the display is not blinking and that output has been restored. (Due to some hysteresis, normal operation may not resume until a frequency slightly above 150 Hz has been reached.).

3. Place the UP/DN switch in the DN position and actuate the PRESET switch. The frequency displayed should be 1200 Hz.

4. Rotate the MANUAL FREQUENCY control clockwise. The displayed frequency should increase and the display should blink if the frequency is increased above approximately 1250 Hz. Verify that output is not displayed on the oscilloscope.

5. Rotate the MANUAL FREQUENCY control counterclockwise until the display stops blinking and the output is restored. This should occur at appoximately 1250 Hz, due to hysteresis.

2.5.4 AUTOMATIC FREQUENCY CONTROL

1. Rotate the MANUAL FREQUENCY control counterclockwise to display 1176.60 Hz, Set the RATE switch to 0.39 Hz/Sec.

2. Place the FREQ SEL switch in the AUTO position. Verify that the displayed frequency increases to and stops at 1200.00 Hz in approximately sixty seconds.

3. Repeat the foregoing with the RATE switch set at 0.01 HZ/SEC and the frequency set manually to 1199.40 Hz and 150.60 Hz. The time to reach the preset limits should remain at appoximately sixty seconds.

2.5.5 OUTPUT LEVEL TRIM

1. Set the UP/DN switch to the UP position, the FREQ SEL switch in the MAN position and actutate the PRESET switch.

2. Turn the VOLTS/HZ control to its counterclockwise limit. Verify that the output level displayed on the oscilloscope is 0.14 volts RMS or less.

3. Turn the VOLTS/HZ control to its clockwise limit. Verify that the output level displayed on the oscilloscope is 0.93 volts RMS or more.

4. Place the UP/DN switch in the DN position and actuate the PRESET switch.

5. Turn the VOLTS/HZ control to its counterclockwise limit. Verify that the output level displayed on the oscilloscope is 4.64 volts RMS or less.

6. Turn the VOLTS/HZ control to its clockwise limit. Verify that the output level displayed on the oscilloscope is 5.43 volts RMS or more.

2.5.6 MULTI-PHASE OUTPUT LEVELS, DISTORTION AND PHASE

1. Connect the oscilloscope between TB1-11 (ground) and TB1-12 and then between TB1-13 (ground) and TB1-14. Verify that the displayed voltage levels are within 0.1% of that measured between TB1-9 and TB1-10 and that all three outputs are free of visible distortion.

2. Connect a phase meter between TB1-10 and TB1-12. Verify a phase angle of 120 ±1 degrees with phase B (TB1-12) lagging phase A (TB1-10).

3. Connect a phase meter between TB1-10 and TB1-14. Verify a phase angle of 120 ±1 degrees with phase C (TB1-14) leading phase A (TB1-10).

2.6 MECHANICAL INSTALLATION AND WIRING

The 836T Oscillator is designed to mount in a standard 19-inch equipment rack. A six-foot power cord is equipped with a polarized male connector that plugs into a 230 volt AC receptacle. A barrier terminal strip (TB1) on the rear panel provides for the output connections as listed in Table 2-1.

2.7 OPERATING CONTROLS

All operating controls and indicators are located on the front panel of the unit as shown in Figure 2-2. Their designations and functional descriptions are listed in Table 2-2.

2.8 OPERATION

The operation of the Model 836T oscillator is relatively simple as explained in the paragraphs that follow. The output level is proportional to frequency although a trim control (VOLTS/HZ) is provided that will adjust the output within the limits shown in Figure 2-3. The normal range of output level is from 0.5 to 5.0 volts over a frequency range of 150 to 1200 Hz.

2.8.1 FREQUENCY PRESET AND LIMITS

The UPPER LIMIT and LOWER LIMIT switches determine the range of the oscillator when operating in the automatic mode. These are adjustable in 1 Hz steps. The absolute limits are 150 to 1200 Hz. The switches may be set to frequencies outside of this range. However, when the selected frequency, in either the automatic or manual mode, is below 150 Hz or above 1200 Hz, the display blinks and the output of the oscillator is inhibited. The switches are usually set to the frequency limits while the unit is in the manual mode (FREQ SEL switch in MAN position). If the UP/DN switch is in the UP position, the frequency readout will display the frequency of the LOWER LIMIT switch when the PRESET switch is actuated. If it is in the DN position, the frequency of the UPPER LIMIT switch will be displayed. An automatic preset is generated at time of initial power application. The result is the same as if the PRESET switch had been actuated.

2.8.2 AUTOMATIC FREQUENCY CONTROL

In the automatic mode, the frequency changes in a direction determined by the position of the UP/DN switch and at a rate

Figure 2-2. Front Panel Controls and Indicators.

Table 2-1. Input/Output Connections.

TB1 PIN NO.	FUNCTION
1	Phase A Output signal low.
2	Phase A Output signal high.
3	Power ground.
4	+25 volt input.
5	-25 volt input.
6	Phase B signal output low.
7	Phase B signal output high.
8	Phase C signal output low.
9	Phase C signal output high.
10	External sync input.
C	115 volts AC line high.
D	115 volts AC line low.

Table 2-2. Control Designations and Functions.

DESIGNATION	FUNCTION
POWER	Toggle switch that applies power to the oscillator. The oscillator will initialize to the frequency of the UPPER LIMIT switch if the UP/DN switch is in the DN position and to the frequency of the LOWER LIMIT switch if it is in the UP position.
FREQ SEL	Toggle switch for selection of manual or automatic frequency control. When in the MAN (MANUAL) position, frequency is adjusted with the MANUAL FREQUENCY control. When in the AUTO (AUTOMATIC) position, the oscillator frequency increases, or decreases, from the displayed frequency to the frequency set in the related LIMIT switch. The direction of frequency change is determined by the position of the UP/DN switch.
UPPER LIMIT	Thumbwheel switch that sets the frequency upon activation of the PRESET switch when the UP/DN switch is in the DN position. This setting is also the upper limit of the frequency sweep when the FREQ SEL switch is in the AUTO position and the UP/DN switch is in the UP position.
LOWER LIMIT	Thumbwheel switch that sets the frequency upon activation of the PRESET switch when the UP/DN switch is in the UP position. This setting is also the lower limit of the frequency sweep when the FREQ SEL switch is in the AUTO position and the UP/DN switch is in the DN position.
UP/DN	Toggle switch for controlling the limit to which the oscillator is preset and for controlling the direction of the frequency sweep in the AUTOMATIC mode of operation.
PRESET	Momentary contact toggle switch that sets the oscillator frequency to that set with the UPPER LIMIT or LOWER LIMIT thumbwheel switches. With the UP/DN switch in the UP position, the PRESET switch will set the frequency to the LOWER LIMIT. The PRESET switch sets the frequency to the UPPER LIMIT when the UP/DN switch is in the DN position.
RATE (HZ/SEC)	Thumbwheel for selection of frequency rate of change while in the AUTOMATIC mode of operation. The rate is adjustable from 0.01 Hz/sec to 0.3 Hz/sec.

Table 2-2. (Continued)

VOLTS/HZ	Potentiometer for offsetting the output voltage at any frequency. The normal voltage sweep is from 0.5 to 5.0 volts. Low trim changes the voltage sweep to be from 0.14 to 4.64 volts. The high trim is from 0.93 to 5.43 volts.
FREQUENCY (HZ)	Five and one-half digit display that indicates the oscillator output frequency.

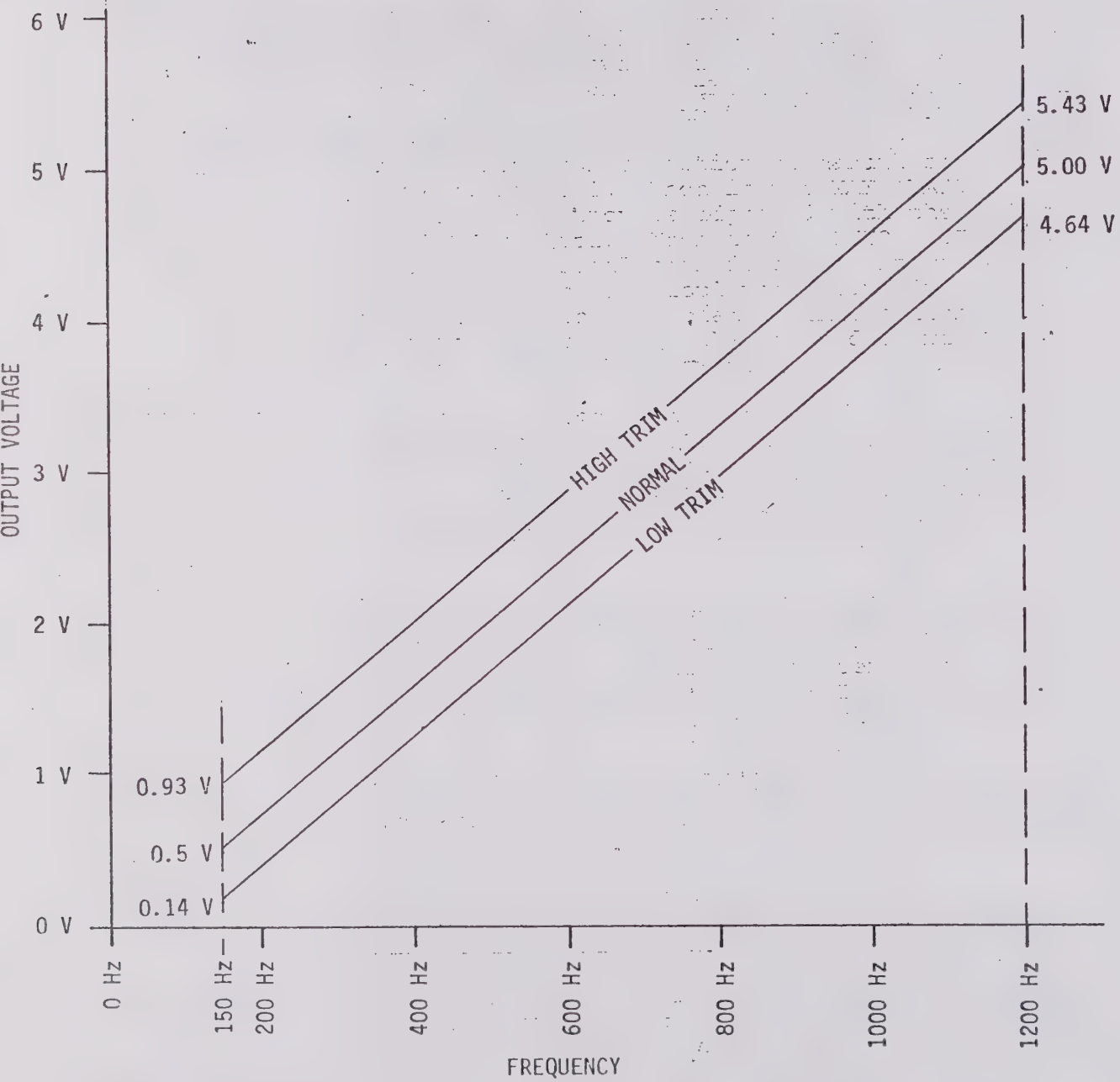

Figure 2-3. Output Trim Values.

determined by the setting of the RATE dial switches. Assume that the FREQ SEL switch is in the MAN position, the UP/DN switch is in the UP position, the RATE switch is set to 0.3 HZ/SEC and the LOWER LIMIT and UPPER LIMIT switches are set to 200 and 1000, respectively. When the PRESET switch is actuated, the frequency displayed will be 200.00 Hz. If the FREQ SEL switch is then placed in the AUTO position, the frequency will immediately increase at the 0.3 Hz/sec rate and stop when the upper limit of 1000 Hz has been reached. If the UP/DN switch is then placed in the DN position, the frequency will decrease at the 0.3 Hz/sec rate and stop when the lower limit of 200 Hz is reached. The frequency sweep in either direction may be halted in mid-range by placing the FREQ SEL switch in the MAN position. Automatic operation is resumed when the FREQ SEL switch is returned to the AUTO position.

2.8.3 MANUAL CONTROL

Manual control of frequency is obtained when the FREQ SEL switch is placed in the MAN position. Rotating the MANUAL FREQUENCY control varies the frequency in 0.01 Hz steps and by 1.27 Hz per revolution. Frequency is increased with clockwise rotation and decreased with counterclockwise rotation. Since large changes of frequency are time consuming when using the MANUAL FREQUENCY control alone, they are usually accomplished by setting one of the limit switches at or near the desired frequency, selecting the proper position of the UP/DN switch and actuating the PRESET switch. Fine frequency adjustment, if required, is then accomplished with the MANUAL FREQUENCY control.

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SECTION III -- THEORY OF OPERATION

3.1 GENERAL

The California Instruments Model 836T Precision Oscillator, because it is controlled by a quartz crystal, provides a degree of frequency stability that surpasses, by an order of magnitude, that which is obtainable with analog types. Amplitude stability is also improved since the output waveform is determined by digital logic circuits. Therefore, the basic "oscillator" is not frequency or temperature sensitive. Output amplitude stability will be affected mainly by frequency and temperature as they affect the output amplifiers. However, such affects are minimal. The optional multi-phase outputs are developed through a single phase to multi-phase converter.

3.2 FUNCTIONAL DESCRIPTION

The functional descriptions of this section are referenced to the block diagrams of Figures 3-1, 3-2 and 3-3.

3.2.1 PHASE A GENERATOR

The following paragraphs present a functional description of the phase A (ØA) generator referenced to the block diagram of Figure 3-1. The crystal oscillator operates at 2.6738688 MHz. A group of four binary rate multipliers control the number of oscillator pulses that will pass to their output per unit time. That number is dependent on the data present on the binary frequency buss. Though not dividers, in the usual sense, the rate multipliers effectively divide the oscillator frequency in accordance with the binary frequency buss data. The number of pulses that appear at the output of the rate multipliers determine the rate at which the address counter is clocked and, therefore, the output frequency of the oscillator.

The address counter consists of two binary counters. The four outputs of each counter are connected to inputs of the programmable read-only memory (PROM) which could provide 256 discrete addresses. However, the comparator and the direction control counter cause the address counter to change its count mode from up to down at counts 255 and 765 and from down to up at counts 510 and 1020. During each complete cycle, at the output frequency, the counters count up from 000 to 255 for the first 255 clock pulses, count down to 000 during the time of clocks 256 to 510, back to 255 during the time of clocks 511 to 765 and back to 000 during the time of clocks 765 to 1020.

At each of the 255 addresses produced by the address counters, a discrete digital code appears at the output of the PROM and at

at the input to the digital-to-analog converter (D/A converter). As the address to the PROM progresses from 000 to 255, the PROM output codes cause the output of the D/A converter to increase in 255 steps that describe the first 90 degrees of a sinusoidal waveform. As it progresses from 255 to 000, while the counter is counting down, the second 90 degrees of a sinusoidal waveform are described. The absolute levels at the D/A converter output are determined by the reference level from the output amplitude control which, in the 836T, is variable with frequency.

The waveform at the output of the D/A converter is similar to that of a sinusoidal waveform after full wave rectification except that it is generated in 510 steps (digitally) rather than as an analog signal. To formulate a quasi-sinusoidal waveform, alternate portions of the D/A converter output must be inverted. Alternate clockings of the direction control counter produce a state change at its output that is connected to the inverting/non-inverting amplifier. The state of the counter output determines whether the amplifier will be in its inverting or non-inverting mode. Since the counter output changes state at the end of each half-cycle, alternate half-cycles of the D/A converter output are inverted and the output of the amplifier is a quasi-sinusoidal waveform which is filtered by the integrating amplifier to produce a sinusoidal waveform with very low distortion.

3.2.2 FREQUENCY LIMITER

The frequency limiter serves to prevent an output from the oscillator if the selected frequency is outside of the range of the associated power source driven by the 836T. The frequency limits are factory adjusted. The limiter consists of two timers and an associated dual flip flop. One timer limits the upper frequency and the other the lower frequency. The signal that clocks the direction control counter also triggers both sections of the frequency limiter, once for each output cycle. If the frequency is too low, one timer will have timed out before the next trigger pulse occurs. This is sensed and disables the reference for the D/A converter, shutting off the output. If the frequency is too high, the second timer will not have timed out before the next trigger pulse. This, too, is sensed and also disables the reference.

3.2.3 MULTI-PHASE OUTPUT GENERATOR

The reference phase, phase A (ØA), is generated by the basic oscillator described functionally in the preceding paragraphs. Phases B and C (ØB and ØC) are generated in the multi-phase generator. Those circuits are shown in block diagram form in Figure 3-2. Note that there are similarities between Figures 3-1

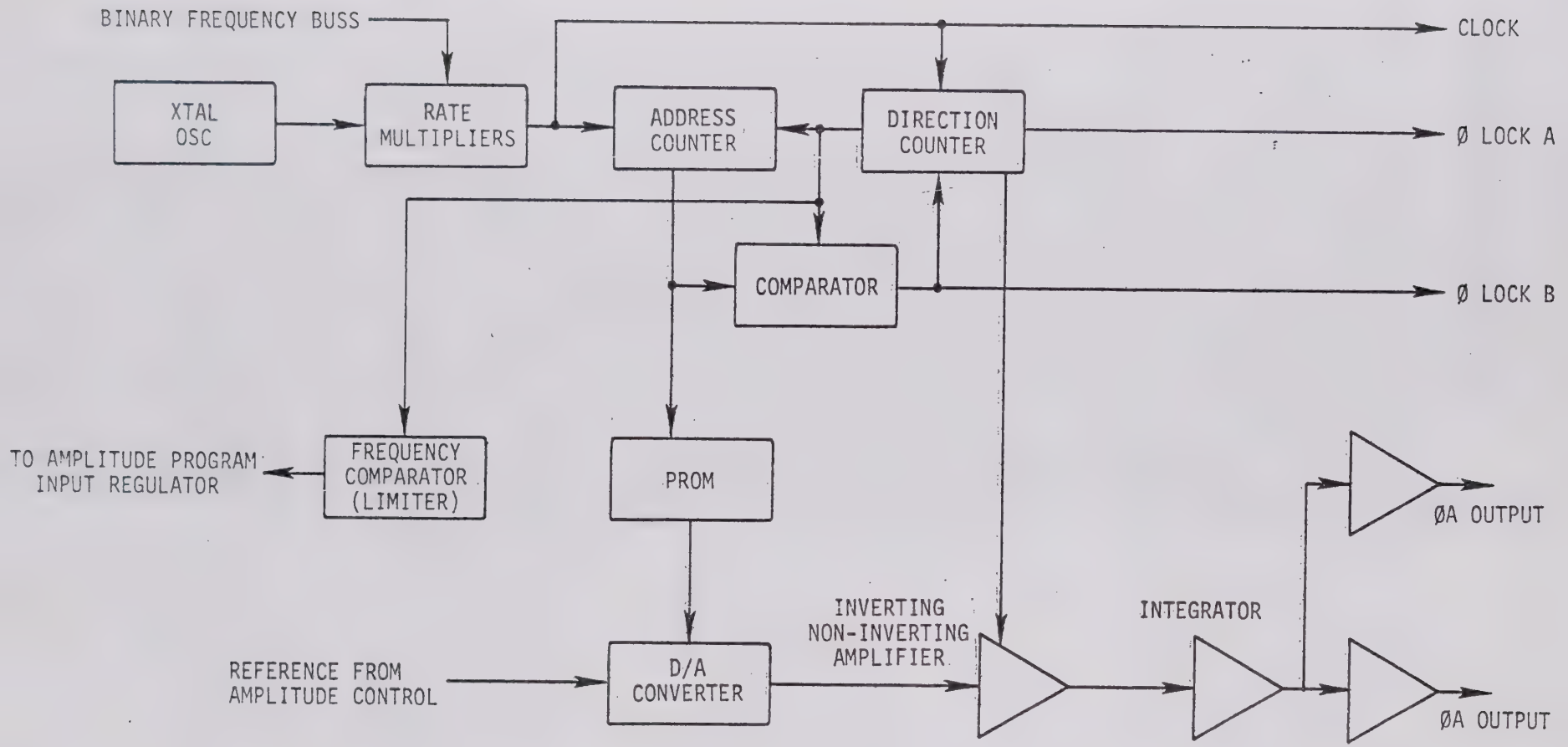


Figure 3-1. Block Diagram, Phase A Generator.

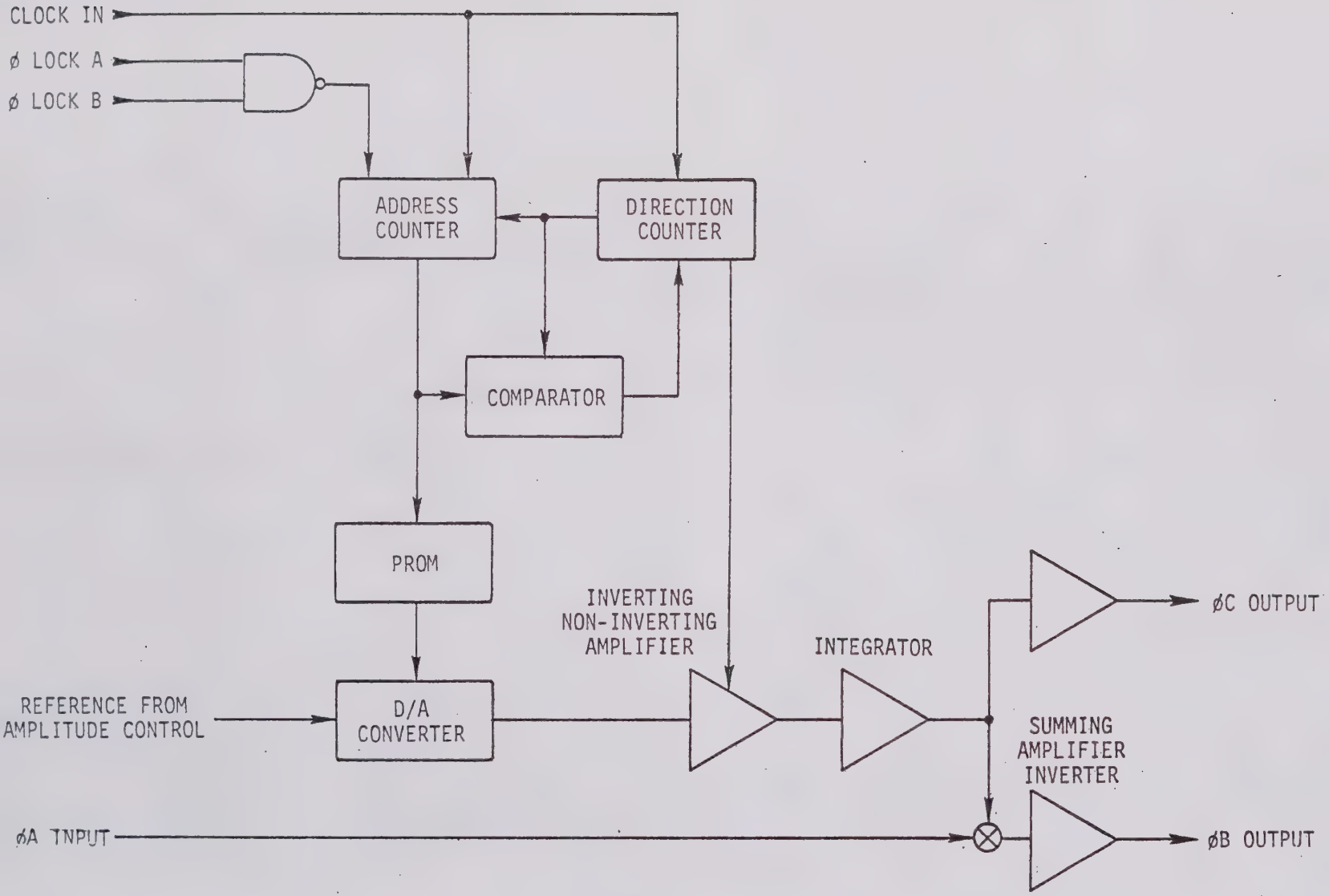


Figure 3-2. Block Diagram, Multi-Phase Generator.

and 3-2 in the counter-PROM-D/A converter areas. The address counters are clocked in the same manner as those of the basic oscillator. However, they are preset coincident with the 180 degree point of the reference phase, ØA, to a number corresponding to the difference between the reference phase and desired angle of phase C (ØC). This is equivalent to 120 degrees with ØC leading ØA. The address counters, direction control counter, PROM, D/A converter and inverting/non-inverting amplifier operate in the same manner as those of the basic oscillator. The output of the ØC inverting/non-inverting amplifier is combined with the ØA output in the phase B (ØB) generator to create the ØB output.

3.2.4 FREQUENCY CONTROL

The system that controls the output frequency of the oscillator is shown in the complete system block diagram of Figure 3-3.

3.2.4.1 MANUAL/AUTOMATIC CONTROL

Control may be either manual or automatic. In the manual mode, the frequency select gates direct pulses from the MANUAL FREQUENCY control to clock the decade up/down counters. The MANUAL FREQUENCY control automatically generates a count-up or count-down signal level for the decade counters depending on the direction of its rotation, irrespective of the position of the UP/DN switch. In the automatic mode, the frequency select gates direct pulses from the auto rate generator to clock the decade up/down counters. The count-up or count-down signal level is determined by the position of the UP/DN switch in the automatic mode.

3.2.4.2 DECADE COUNTER SYSTEM

The decade up/down counter system consists of six 4-bit, BCD counters. The normal range of counts is from 15,000 to 120,000 although they may be clocked to values outside this range. The counters may be preset, by actuating the PRESET switch, to the value of either the UPPER LIMIT and LOWER LIMIT switches, depending on the position of the UP/DN switch. The outputs of the decade up/down counters are applied to the display, to show the selected frequency, and to the BCD-to-binary converter.

3.2.4.3 LIMIT SELECT AND COMPARATOR SYSTEMS

The limit select system consists of two sets of four BCD thumbwheel switches for setting the upper and lower frequency limits along with the PRESET switch and a steering flip flop, controlled by the UP/DN switch. In the manual mode, this system permits the operator to select and preset any frequency within

the operating range. In the automatic mode, it permits the operator to select the upper and lower frequency limits of a frequency sweep, also within the operating range. Although the limit switches may be set to a frequency outside of the operating range of the frequency limiter described in 3.2.2 and the frequency so selected will be displayed. However, the display will blink, indicating that the output has been inhibited. On power-up, a preset signal is automatically produced to preset the decade up/down counter system to the frequency selected by one of the sets of limit switches. If the UP/DN switch is in the DN position, the preset will be at the frequency of the UPPER LIMIT switch settings. If it is in the UP position, the preset will be at the frequency of the LOWER LIMIT switch settings. The operator may preset the output frequency by setting a limit switch to the desired value, placing the UP/DN switch in the appropriate position and actuating the PRESET switch. If the system is in the manual mode, the frequency will remain fixed unless the MANUAL FREQUENCY control is rotated. If it is in the automatic mode, the frequency will be swept from the selected limit to the limit set with the other limit switches.

The BCD count of the limit switches and those of the decade up/down counter outputs are applied to the comparator. When the UP/DN switch is in the UP position, the limit input is from the UPPER LIMIT switches. When the count of the up/down counters reaches that of the limit switches, the output of the comparator, which is applied to the frequency select gates, changes states. If the system is in the automatic mode, it will inhibit the auto rate generator pulses from further clocking the decade up/down counters, limiting the upper limit of the frequency sweep. Operation is similar when the UP/DN switch is in the DN position. In that case, the LOWER LIMIT switches are effective. In the manual mode, the output of the comparator has no effect and the frequency may be increased above or below the set limit.

3.2.4.4 DISPLAY

One two-segment and five seven-segment devices provide for the five and one-half digit display of frequency. They are driven by six BCD-to-seven-segment decoder/drivers that have their inputs connected to the decade up/down counter outputs. The enable for the display decoder/drivers is passed through an enabling gate blinker. When the displayed frequency is within the operating range, the decoder/driver is enabled and the display is steadily illuminated. When the displayed frequency is outside of the operating range, the input from the frequency limiter causes the enable to the decoder/drivers to be periodically interrupted, causing the display to blink. The blink rate signal is obtained by dividing the 2.67 MHz oscillator signal to 5 Hz through two binary counters.

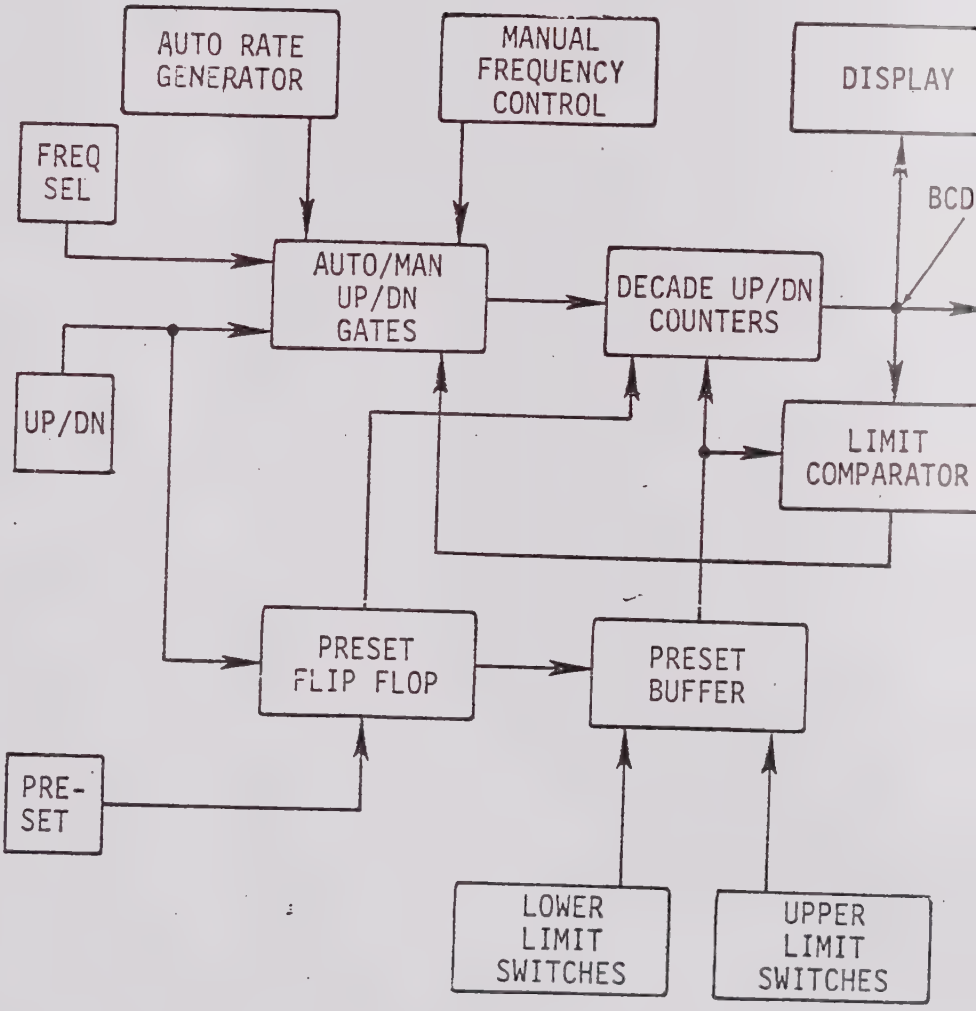
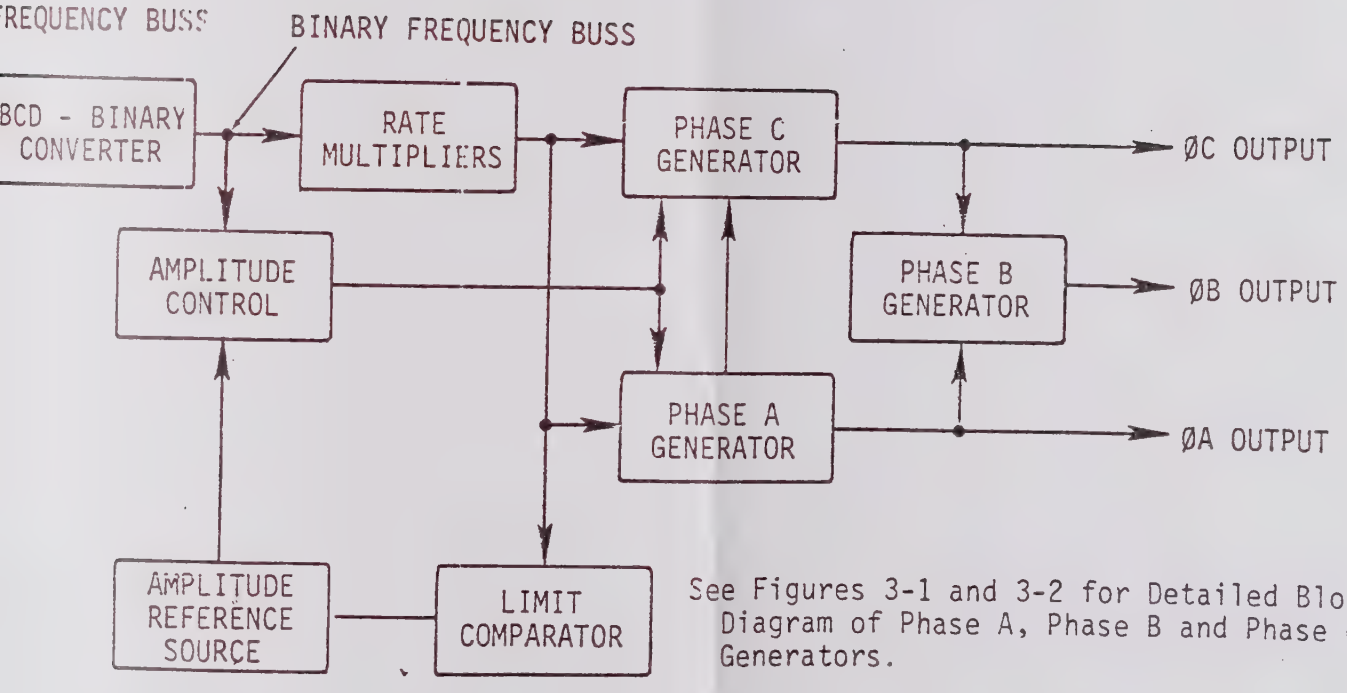


Figure 3-3. Bloc



See Figures 3-1 and 3-2 for Detailed Block Diagram of Phase A, Phase B and Phase C Generators.

Diagram, Model 836T Precision Oscillator.

3.2.4.5 OUTPUT AMPLITUDE CONTROL

The amplitude control system receives its input from the BCD-to-binary converter. It consists of digital-to-analog converters (D/A converters) and a summing amplifier. The output of the D/A converter is proportional to its address input. Therefore, it is proportional to the selected frequency. The output of the amplitude control system provides the DC input to the D/A converters of the øA and øC generators, in turn, controlling their output amplitudes, and that of the øB output, as a function of frequency.

3.3 DETAILED CIRCUIT DESCRIPTION

The paragraphs of this section describe in detail the operation of the circuits of the Model 836T Precision Oscillator. Unless otherwise specified, all text within this section is referenced to the schematic diagrams of Figures 7-5, 7-6 and 7-7. Where components consist of several discrete circuits within a single package, the individual circuits are identified in the text by the basic component identifier followed by a hyphen and the output pin number. For example, the buffer in U20 that has its output connected to pin 4 is identified as U20-4. If this device is located on circuit board A1, its complete identifier is A1U20-4. However, the prefix is used in the following paragraphs only when necessary to avoid confusion in identifying similarly numbered components located on different boards.

3.3.1 PHASE A GENERATOR

3.3.1.1 CRYSTAL OSCILLATOR

Refer to Figure 7-5. Crystal Y1, FET Q5 and associated components comprise an oscillator operating at 2.6738688 MHz. The oscillator output is buffered by U21-2 and U21-4 which convert the oscillator output to a series of TTL compatible pulses.

3.3.1.2 RATE MULTIPLIERS

A complete explanation of the operation of rate multipliers may be found in material published by the device manufacturer. Therefore, the explanation of the rate multiplier circuits herein is limited to that which is peculiar to this design.

A single binary rate multiplier, such as used in the 836T, may block pulses appearing at its input from reaching its output or it may pass from one to sixty-three pulses for every sixty-four input pulses, depending on the states of its control inputs. In the 836T oscillator, the control inputs of the rate multipliers,

U22, U23 and U24, are connected to the binary frequency control buss, allowing from 1 to 262142 pulses for every 262144 pulses to reach the output. Rate multiplier U22 is enabled at all times. From zero to sixty-three pulses will appear at its output, pin 7, during the time of each group of sixty-four oscillator pulses. The actual number will depend on the states of frequency control buss lines A12 through A17. During the time of the sixty-fourth oscillator pulse, its enable output, pin 7, goes low, enabling the next rate multiplier, U23. U23 counts the enable input pulses in the same manner that U22 counted the oscillator pulses. The number that pass to its output will be dependent on the states of frequency control buss lines A6 through A11. However, the output pulse will have the timing and duration of the clock oscillator pulse which is an input to each rate multiplier. This provides synchronization and uniformity of the pulses at the outputs of the mulitipliers. U23 counts the enabling outputs of U22 and U24 counts those from U23. The output pulses from the rate multipliers are then summed through NAND gate U31-6.

3.3.1.3 ADDRESS AND DIRECTION CONTROL COUNTERS

Refer to Figure 7-7. The address counters, U1 and U2, are so called since they produce the address for the two programmable memories (PROM's) U4 and U5. They are binary counters that are synchronously clocked by the output of U31-6 (shown in Figure 7-6). However, U2 is enabled by the output of U1 only between the rising edges of the 15th and 16th clock pulses and will be clocked by the rising edge of the 16th pulse. Therefore, U1 must be clocked 16 times for U2 to be clocked once 32 times for it be clocked twice, etc. The four stage outputs of U1 and U2 are connected to the eight inputs of U4 and U5 providing 256 discrete memory addresses.

The array of exclusive NOR gates, U16 and U17, are open-collector types and their combined outputs go high, producing ø LOCK B, when all its inputs are the same, high or low. ø LOCK B occurs when U3-14 (Q0) is high and all stage outputs of U1 and U2 are high, except U1-14 (Q0), at counts 254 and 764. It also occurs when U3-14 is low and all stage outputs of U1 and U2 are low, except U1-14, at counts 509 and 1019. ø LOCK B is an input to the multi-phase converter and to counter U3. U3 is enabled through inverter U20-8 when ø LOCK B goes high and is then clocked once simultaneously with U1 and U2 at clock pulses 255, 510, 765 and 1020. U1 and U2 are advanced one count, since their up/down inputs do not change state until after this clock pulse. The inputs to U16 and U17 are then no longer the same and ø LOCK B goes high, disabling U3. However, U3 was clocked once, changing the state of its Q0 output, pin 14, and the up/down inputs of U1 and U2. The count modes of U1 and U2 are then changed from up to down if pin 14 of U3 goes low or from down to

up if it goes high. Thus U1 and U2 are forced to count up from count 001 to count 255, down from count 256 to 510, up from count 511 to 765 and down again from count 766 to 1020. The rate at which this occurs is determined by rate of the pulses coming from the rate multipliers which, in turn are controlled by the states of the lines of the frequency control bus.

Counter U3-13 has its output connected to FET Q1. The purpose of this connection is covered in a later paragraph. Its terminal count output, pin 15, goes low every 4060 counts to provide ø LOCK A which is an input to the multi-phase converter in paragraph 3.3.3.

3.3.1.4 QUASI-SINUSOID GENERATION

The digital-to-analog converter (D/A converter), U6, and the two amplifiers of U7 generate a quasi-sinusoidal waveform, consisting of 1020 discrete steps, in response to the inputs from programmable memories (PROM's), U4 and U5. The DC input for the D/A converter is obtained from the output of operational amplifier U27 (shown in Figure 7-6). The output level of U27 will vary with the adjustment of the front panel vernier control and the D/A converter output from U25 and U26. The D/A converter output level will be proportional to the selected frequency. Nominally, this voltage is variable over a 0 to 10 volt range.

The PROM outputs provide the digital input codes for the D/A converter. From the previous paragraphs, it should be apparent that the address for the PROM'S is being repeatedly incremented from 000 to 255 and then decremented from 255 back to 000. Thus, the digital input codes to the D/A converter are, likewise, being incremented and decremented. The PROM's are programmed in such a manner that, as their addresses are incremented from 000 to 255, their outputs cause U6 to produce what comprises the first 90 degrees of a quasi-sinusoidal waveform consisting of 255 discrete steps. The amplitude of each step is equivalent to:

sin (90/255 x A)

Where A is the discrete digital address (000 to 255).

As the address is decremented from 255 back to 000, U6 produces the opposite waveform which is the second 90 degrees (91 to 180 degrees) of a quasi-sinusoidal waveform. The process of address incrementing and decrementing is repetitive. Therefore, in two complete cycles, U6 produces what appears as a sinusoidal waveform after full wave rectification except that it consists of 1020 discrete steps rather than being a pure analog signal. It is only necessary to invert alternate cycles of U6's output to achieve a quasi-sinusoidal waveform. This is accomplished in the amplifiers of U7,

FET Q1 grounds the connection between R4 and pin 5 of U7 whenever its gate is at +5 volts, changing the two sections of U7 from a non-inverting amplifier to an inverting amplifier. In a previous paragraph, it was stated that counter U3 was clocked once at counts 255, 510, 765 and 1020. Its QB output, pin 13, therefore, will change state at counts 510 and 1020. Pin 13 of U3 is connected to the gate of FET Q1. Whenever it is low, Q1 is turned off and U7 does not invert the output of U6. When it is high, Q1 is turned on and U6's output is inverted. A complete cycle for U6 occurs between counts 000 and 510 and between 510 and 1020. Thus, alternate cycles will be inverted to form a quasi-sinusoidal waveform at the output of U7. R31 provides a means of equalizing the amplification of U7 in its inverting and non-inverting modes so that the alternate half-cycles of the quasi-sinusoidal waveform are equal in amplitude. The output of U7 is then integrated in U68-1 to provide a ØA OUTPUT which is a sinusoidal waveform with very low distortion. The signal at pin 3 of U68 is sinusoidal and is passed through U68-7, which has unity gain, to provide the ØA output of the oscillator.

3.3.2 FREQUENCY DETECTOR

The purpose of the frequency detector is to prevent production of an output frequency above or below the range of the AC power source that is driven by the 836T. Its circuit is shown in Figure 7-7 and is comprised of transistors Q3 and Q4, dual timer U28, dual flip flop U30 and NAND gate U55-11 and associated components. The Q1 output of counter U3 (pin 14) transitions from high to low once for every half-cycle of the output frequency. This pulse clocks both sections of U28, momentarily turns on Q3 and Q4 to discharge timing capacitors C22 and C23 and triggers both timers of U30. The section of U30 associated with Q4 is adjusted with R35 so that its time period is greater than one half-cycle of the lowest permissible output frequency. As long as the output frequency of the 836T is greater than this low limit, the output of the timer will be high when the next trigger pulse from U3 occurs. The Q output of flip flop U30-1 will not change state and the input of U55-11 connected to it, will remain high. The section of U30 associated with Q3 is adjusted with R36 so that its time period is less than one half-cycle of the highest permissible output frequency. As long as the output frequency of the 836T is less than this high limit, the output of the timer will have transitioned from high to low before the next pulse from U3 occurs. The Q output of U30-13 and the input to U55-11 connected to it will remain high.

Refer to Figure 7-6. While the frequency remains within the set limits, the output of U55-11 (shown in Figure 7-7) will be low (all its inputs are high) and Q6 will be turned off and Q9 will be turned on, completing the path from the +15 volt input to 10

volt regulator U29 which provides the DC input to D/A converter U25. If the selected frequency is below the set limit, pin 5 of U28 will go low before the next pulse. The Q output of U30-2 (Figure 7-7) will be clocked low. The output of U55-11 will go high turning on Q6, turning off Q9 and the DC supply to 10 volt regulator U29 which furnishes the input voltage to D/A converters U25 and U26. Refer to Figure 7-7. If the selected frequency is higher than the set limit, pin 9 of U30-13 will be high at the time of the next pulse and the Q output of U28-9 will be clocked low. The output of U55-11 will go high turning on Q6, turning off Q9 and the DC supply to U29 and the D/A converter.

Refer to Figure 7-7. A "soft start" feature is incorporated in the frequency limiter circuit that gradually increases the voltage applied to U29 when the unit is first started and whenever it returns to operation after shutting down because of an out-of-limit frequency condition. Q6 will be turned on when power is applied or when an out-of-limit frequency is selected. When it is turned off, the drain of Q9 will follow the exponentially increasing voltage at the junction of R23 andC35. Thus, the voltage applied to U29 will slowly increase from zero to +15 volts and the output of the D/A Converter will, likewise, slowly increase.

3.3.3 MULTI-PHASE CONVERTER

The multi-phase converter develops a second sinusoidal waveform, designated as phase C (øC) which is combined with øA to produce phase B (øB). The following paragraphs explain the functioning of the multi-phase converter.

3.3.3.1 PHASE C GENERATOR

The phase C generator is shown in Figure 7-7. It consists of address counters, a directional control counter system, PROM's, a D/A converter and an inverting/non-inverting amplifier that perform the same functions as those on the øA generator that were decribed in previous paragraphs. The circuits, comprised of counters U8, U9 and U10, exclusive NOR gates U18 and U19, PROM's U11 and U12 D/A converter U13 and operational amplifier U14 are interconnected in the same manner as their counterparts in the øA generator. The counters are clocked by the same signal from U31-6. The DC input for the D/A converter is also obtained from amplifier U27. Thus, the amplitudes of the øA and øC outputs will be identical. R15 provides a fine adjustment of the øC amplitude.

The counters of the multi-phase converter, unlike those of the oA generator, are preset at the instant the øA output passes through

the 360/0 degree point on every fourth cycle. The preset causes the waveform generated in this system to be displaced, relative to øA such that it lags øA by 120 degrees. The preset is accomplished by $\overline{\text{ø LOCK A}}$ and ø LOCK B through U20-6 and U31-12. ø LOCK A goes low one clock pulse prior to the end of every fourth cycle of the output frequency (4078 clock pulses from the output of U31) and remains low for the next complete cycle. ø LOCK B, as described in preceding paragraphs, goes high at counts 254, 509, 764 and 1019. Therefore, it goes high at counts 2039, 3059 and 4079. When $\overline{\text{ø LOCK A}}$ is low and ø LOCK B goes high, the preset mode of counters U8, U9 and U10 are enabled and preset occurs on the rising edge of the next clock pulse. The counters are preset to the count determined by the connections to their A, B, C and D inputs. The A and C inputs of U8 and U9 are grounded (low) and the B and D inputs are at +5 volts. This produces a preset of AA in hexidecimal or 1010 1010 in binary. This presets the PROM address at 170. The directional control counter, U10, is preset so that its QA output is high and its QB output is low. Thus, counters U8 and U9 will be in the count-up mode and U14 will be in its non-inverting mode. The amplitude of the waveform developed at the output of U13 from this point forward will be increasing from zero toward maximum and, since U14 is in a non-inverting mode, the output of U14 will be 120 degrees leading øA which is the correct phase angle for øC. The signal output of U14 is buffered by U69-7 to provide øC OUTPUT. Capacitor C18 provides high frequency roll-off for U69-7.

3.3.3.2 B PHASE GENERATOR

The øB signal is obtained by summing øA and øC signals of equal amplitudes and then inverting the resultant signal through an operational amplifier. The øA OUTPUT signal input to this board is obtained from amplifier U68-1 which isolates it from the øA OUTPUT signal to the power source which is obtained at the output of U68-7. The øC signal is obtained from the output of amplifier U69-1. The two signals are summed at the input of amplifier U15-1 through the resistor network of R12. R34 provides a fine adjustment of the øB angle and R17 provides a fine adjustment of the øB signal at the output of U15-1.

3.3.4 FREQUENCY CONTROL

Frequency control of the 836T is a complex process involving several sub-systems including some that are described in previous paragraphs. This sub-section describes the systems that control the decade counters, the decade-to-binary conversion system and control of the rate multipliers described in 3.3.1.2.

3.3.4.1 DECADE COUNTER SYSTEM

The decade counter system is shown in Figure 7-5. It includes counters U33 through U38, which drive the frequency display

system and provide inputs to the decade-to-binary converter and frequency limit systems. These are presettable, up/down counters. When the PRESET switch is closed, the low at the D input of flip flop U58-13 will be clocked through to its Q output by the next pulse from counter U71 (shown in Figure 7-6). The $\overline{Q}$ output is forced high, causing counters U33 through U36 to be preset to the BCD codes appearing on the BCD preset bus. These codes are generated by the circuits associated with the preset limit switches described in 3.3.6. When the PRESET switch is released, the $\overline{Q}$ output of U58-13 is clocked low, disconnecting the preset inputs of the counters from the preset bus. The decade up/down counters will then be clocked up or down by clock pulses generated manually or automatically as described in 3.3.4.3 and 3.3.4.4.

3.3.4.2 DECADE TC BINARY CONVERSION

The BCD output of the decade up/down counters is converted to binary. The decade-to-binary converter output provides the input for the rate multipliers and the digital-to-analog converters that vary the oscillator output amplitude in proportion to the output frequency.

The outputs of up/down converters U33 through U38 are connected to the preset inputs of BCD down counters U43, U44 and U45 (shown in Figure 7-6). The three down counters are clocked by a 333 KHz pulse train out of counter U71 which is driven by the 2.67 MHz crystal oscillator. The down counters are preset by the output of U43, pin 14 when all counters have been clocked to zero. Simultaneously, the binary up counters, U46 and U47, are reset to zero with the same pulse through inverter U56-2, NAND gate U54-4 and inverter U56-6. Both sets of counters are then clocked by the same signal. Therefore, the number of counts accumulated by the binary counters will be the same as required to clock the BCD down counters from their preset value to zero. The reset pulse also clocks quad flip flops U48, U49 and U50 to store the output of the binary counters. Thus, the binary frequency data buss is updated with each reset of the counters. Since the time required to count-down from the maximum number (120,000) is 0.36 seconds, the up-date of the binary frequency data is near-instantaneous.

3.3.4.3 MANUAL FREQUENCY CONTROL

The following paragraph describes only those circuits that generate the clock pulses for counters U33 through U38 when the system is operating in the manual mode with the FREQ SEL switch, S3, placed in the MAN position.

The MANUAL FREQUENCY control is an electro-optical device that generates a string of overlapping pulses when its shaft is

rotated. When it is rotated to the right, terminal A will already be high when terminal B goes high. When it is rotated to the left, terminal A will go low before terminal B goes high. As it is rotated to the right, counters U33 through U38, through NAND gates U54-11 and U54-3, are placed in the count-up mode by a high state at terminal A before the pulse at terminal B occurs, which clocks the counters through inverter U56-12 and NAND gates U55-10 and U55-4. Therefore, the counters are clocked up. As the control is rotated to the left, the counters are in the count-down mode, at the time of the leading edge of the pulse at terminal B, since terminal A is low. Therefore, the counters are clocked down. Thus, the operator may increase or decrease the frequency by the direction in which he rotates the frequency control.

3.3.4.4 AUTOMATIC FREQUENCY CONTROL

The following paragraph describes only those circuits that generate the clock pulses for counters U33 through U38 when the system is operating in the automatic mode with the FREQ SEL switch in the AUTO position.

When the FREQ SEL, S3, switch is in the AUTO position, the output of exclusive OR gate U53-11 is forced high, enabling timer U57. U57 is connected as an oscillator with its pulse repetition rate controlled by switches A3S2A and A3S2B and the manner in which they connect resistors A3R1 through A3R6 in parallel (see Figure 7-5). The output pulses from U57 pass through NAND gate U55-4 to clock counters U33 through U38. With S3 in the AUTO position and the UP/DN switch in the UP position, the output of NAND gate U54-10 is forced high placing the counters in the count-up mode. When the UP/DOWN switch is in the DOWN position, the output of U54-10 is forced low placing the counters in the count-down mode. In the automatic mode, the timer will be disabled when the frequency reaches the preset limit as described in paragraph 3.3.6. Switches S4 and S5 adjust the rate from 1 to 30 Hz/sec. Thus the rate of frequency change is adjustable from 0.01 Hz to 0.3 Hz/sec.

3.3.5 FREQUENCY DISPLAY

The operating frequency is visible on a five and one-half digit, LED display shown schematically in the A2 section of Figure 7-5. The data on the BCD frequency buss provides the input to a set of BCD-to-seven-segment decoder/drivers, U1 through U'6, which drive the display devices, DS1 through DS6. DS1 is a one-half digit display that shows only the numeral 1. The others display any numeral from 0 to 9.

3.3.6 PRESETTABLE FREQUENCY LIMITER

The presettable frequency limiter operates independently of the frequecy detector described in 3.2.2, but cannot override it. It allows the operator to preset the lower and upper limits of frequency that will be attained while operating in the automatic mode. Two sets of four thumbwheel switches each provide for the operator input.

Refer to section A3 of Figure 7-5. S1 is the UPPER LIMIT switch set and S6 is the LOWER LIMIT switch set. When the output of exclusive OR gate U53-3, LOW LIMIT ENABLE, low, Q7 is turned off and Q8 is turned on. This enables the UPPER LIMIT switches. The sections of R52 and R53, that are connected through S5, serve as the collector resistor for Q8. When the LOW LIMIT ENABLE line is high, Q8 is turned off and Q7 is turned on, enabling the LOWER LIMIT switches. The sections of R52 and R53, that are connected through S6, serve as the collector resistor for Q7. The individual switches are BCD coded. The outputs of S5 and S6 are connected to the LIMIT DATA buss through the AND gates of U59, U60, U61 and U55-3.

Actuating the PRESET switch causes the Q output of flip flop U58-13, which is clocked by the Q6 output of counter U71 (Figure 7-6), to go low and the Q output to go high, enabling the LOWER LIMIT switches. The Q output of U58-13 is then low and the preset inputs of decade counters U33 through U36 are enabled. When the UP/DN switch is in the UP position, the counters (and the oscillator frequency) are then preset to the setting of the LOWER LIMIT switches. When the PRESET switch is released, the LOW LIMIT ENABLE line goes low, disabling the LOW LIMIT switches and enabling the HIGH LIMIT switches. The enabling signal to the preset inputs of the decade up/down counters is also removed.

Refer to Figure 7-6. The states of the HIGH LIMIT switches are on the LIMIT DATA buss. These are inputs to 4-bit magnitude comparators U39, U40 and U41. The other inputs to the comparators are from the decade up/down counters, U33 through U36 of Figure 7-5. The $A > B$ and $A < B$ outputs of U39, U40 and U41 are connected as inputs to comparator U42. When the decade up/down counters have been clocked to the same value as the LIMIT PRESET buss, the $A < B$ output of U42 goes low. NAND gate U52-10 is enabled and NAND gate U52-11 disabled when the UP/DN switch is in the UP position. When pin 7 of U42 goes low and the FREQ SEL switch is in the AUTO position, the output of exclusive OR gate U53-11 is forced low, turning off timer U57 and stopping generation of decade up/down counter clock pulses. Thus the frequency increase, in the automatic mode, is halted when the frequency reaches the preset limit. Note that when the FREQ SEL switch is in the MAN position, the output of NAND gate U52-3 is

forced high, forcing the output of U53-11 low. Therefore, in the manual mode, the limit system is disabled. The frequency of the oscillator can be manually increased or decreased beyond the preset limits. However, if it increased or decreased beyond the set limits of the limiter described in 3.2.2, the output will be inhibited. This is indicated by a blinking display.

When the UP/DN switch is in the DN position, the operation is quite similar. However, the output of U53-3 is forced low when the UP/DN switch is placed in the DN position and transitions to high when the PRESET switch is actuated. This places the states of the UPPER LIMIT switches on the LIMIT PRESET buss. The decade up/down counters and the oscillator frequency will then be preset to the UPPER LIMIT. When the preset switch is released, the states of the LOWER LIMIT switches are on the PRESET LIMIT buss. When the decade up/down counters are clocked to the low limit, the A > B output, pin 5 of U42, goes low and, through NAND gate U52-11, forces the output of U53-11 low, stopping timer U57.

When power is first applied, U58-13 is reset through C30, forcing its $\overline{Q}$ output low. This presets the counters to the value to which the limit switches that are enabled by the postion of the UP/DN switch are set

3.3.7 OUTPUT AMPLITUDE CONTROL

The output level of the 836T is proportional to the output frequency as shown in Figure 2-2. A front panel trim adjustment, VOLTS/HZ, allows the ramp to be offset at any point between the limits shown.

Refer to Figure 7-6. +15 volts DC is applied to regulator U29 through FET Q9. U29 provides regulated 10 volts DC to the inputs of both digital-to-analog converters (D/A converters) U25 and U26. The D/A converters are addressed by the output of the decade-to-binary converter with U25 having the most significant data. The D/A converters produce a DC current directly proportional to the value of the binary input. Ignoring the influence of U26, for the moment, current out of U25 is converted to a voltage level at the output of operational amplifier U27 which, in turn, is the DC input voltage for the two D/A converters, U6 and U13, in the analog system of Figure 7-7. Therefore, as the binary frequency address changes (increases or decreases), the oscillator output amplitude also changes (increases or decreases).

Returning to U26, it produces the same output current as U25. However, the weight of the binary inputs to U26 are 1/256th of the same input to U25. Through U32 and resistors R20 and R21, the current summed with that from U25 is reduced to 1/256th of

that at the output of U26. The offset of the ramp, shown in Figure 2-2, is accomplished with R1 at the non-inverting input of U27.

The input to D/A converters U25 and U26 rises slowly when power is first applied or when the system is restarted after a frequency-out-of-limit shutdown.

3.3.8 EXTERNAL FREQUENCY MONITOR OUTPUT

Pin 9 of direction control counter U3, shown in Figure 7-7. changes state twice for every cycle of the output frequency. It is, then, a square wave at the output frequency. Pin 9 of U3 is connected to photo-coupler U72 through inverter U21-12 and R58. When a 5 volt DC source is properly connected between terminals 4 and 6 of TB1, the output side of U72 is energized andan isolated reproduction of the output frequency square wave appears between terminals 4 and 5. A frequency counter connected between terminals 4 and 5 will display the output frequency.

Table 4-2. Sample Test Data Sheet.

PARAMETER	LIMITS	MEASURED
Crystal Frequency	2.6738821 MHz to 2.6738555 MHz	
Volts/Hz Trim (1200 Hz)		
High	Greater than 5.43 V RMS	
Low	Less than 4.57 V RMS	
Harmonic Distortion		
øA	Less than 0.3% THD	
øB	Less than 0.3% THD	
øC	Less than 0.3% THD	
Phase Angle		
øA to øC	119 to 121 degrees øA lagging øC	
øA to øB	239 to 241 degrees øA lagging øC	
Output		
øA (150.00 Hz)	Adjust to 0.500 V RMS	
øB (150.00 Hz)	0.495 to 0.505 V RMS	
øC (150.00 Hz)	0.495 to 0.505 V RMS	
øA (1200.00 Hz)	5.000 0.005 V RMS	
øB (1200.00 Hz)	5.000 0.005 V RMS	
øC (1200.00 Hz)	5.000 0.005 V RMS	

SECTION IV -- ADJUSTMENT PROCEDURE

4.1 GENERAL

The following adjustment procedure, or any part of it, may be performed on a routine basis to insure that the oscillator remains within specified performance limits. The procedure should always be performed after service to the oscillator.

The procedure includes a check of the crystal oscillator frequency, adjustment of output levels for all phases and adjustments to minimize distortion. In addition, checks and adjustments for the output volts/Hz trim limits are provided as is a check of the frequency sweep rate in the automatic mode.

If the equipment fails any of the following tests, refer to Section V of this manual for troubleshooting procedures.

4.2 EQUIPMENT REQUIRED

The following items of equipment will be required for making the checks and adjustments:

Digital Multimeter -- California Instruments Model DMM-53 or equivalent.
Oscilloscope -- Tektronix Model 7000 with a 7553 time base and 7A18 amplifier, or equivalent.
Differential Phase Meter -- Dranetz Model305 with PA3001 plug-in, or equivalent.
Distortion Analyzer -- Hewlett Packard 333A, or equivalent.

4.3 PROCEDURE

4.3.1 POWER SUPPLY ADJUSTMENT

The power supply is a separate module mounted on the inside of the rear panel. The locations of the supply connections to the main board, A1, are shown in Figure 7-2. Connect the digital multimeter between these connections and ground to measure the power supply output voltage. Included in this manual, as Figures 7-9 and 7-10, are reproductions of the power supply manufacturer's specification sheet which includes a diagram showing location of the three voltage adjustments. Table 4-1 lists the required voltage limits and identifies the adjustment by schematic reference designator.

Table 4-1. Power Supply Voltages and Limits.

SUPPLY	ADJUSTMENT	VOLTAGE/LIMITS
+5 VDC	R9	+5 ± 0.1 VDC
+15 VDC	R17	+15 ± 0.1 VDC
-15 VDC	R19	-5 ± 0.1 VDC

4.3.2 OSCILLATOR CHECKS AND ADJUSTMENTS

The adjustments for the oscillator are located on the main board, A1. Table 4-2 is a sample test data sheet of the type on which all test data should be recorded.

4.3.2.1 RELIMINARY CONTROL SETTINGS

The tests and adjustments of this section should be performed in the order presented. Prior to performing the procedure, set the front panel controls as follows:

FREQ SEL switch -- MAN
UP/DN switch -- DN
VOLTS/HZ control -- Midrange
UPPER LIMIT switches -- 1200
LOWER LIMIT switches -- 0150
RATE (HZ/SEC) -- .39

4.3.2.2 RYSTAL FREQUENCY CHECK

The crystal frequency check insures that the 836T output frequency is within 0.005% of that displayed on the front panel. There is no adjustment for the crystal oscillator frequency. If the frquency is out of limits it may be necessary to change C26 to restore the correct frequency.

Connect the frequency counter between P3 and ground. Verify that the indicated frequency is within the limits of 2.6738821 MHz and 2.6738555 MHz.

4.3.2.3 VOLTS/HZ RATIO CHECK AND ADJUSTMENT

Momentarily depress the PRESET switch. Verify that the displayed frequency is 1200.00 Hz. Connect the digital voltmeter to the phase A output, terminals 9 (ground) and 10 of TB1. Rotate the VOLTS/HZ control to its clockwise limit. Verify that the meter reading is greater than 5.43 volts RMS. Turn the control counterclockwise and verify that the meter reading is greater than 5.43 volts RMS. Turn the control counterclockwise and verify that the meter reading is less than 4.57 volts RMS.

Readjust the VOLTS/HZ control for a 5.00 volts RMS meter reading.

4.3.2.4 PHASE A CALIBRATION

Connect the distortion analyzer to the phase A output, terminals 9 (ground) and 10 of TB1. Adjust R30 and R31 to achieve the lowest possible total harmonic distortion (THD) reading. The reading should be less than 0.3% THD.

Set the oscillator frequency to 150.00 Hz by placing the UP/DN switch in the UP position and actuating the PRESET switch. Connect the multimeter to the phase A output. Adjust the VOLTS/HZ control for a meter reading of 0.500 volts RMS. Change the frequency to 1200.00 Hz and adjust R7 for a meter reading of 5.00 volts RMS.

4.3.2.5 PHASE C CALIBRATION

Connect the distortion analyzer to the phase C output, terminals 13 (ground) and 14 of TB1. Adjust R32 and R33 to achieve the lowest possible THD reading. The reading should be less than 0.3% THD.

Set the oscillator frequency to 150.00 Hz. Connect the multimeter to the phase C output and adjust the VOLTS/HZ control for a reading of 0.500 volts RMS. Change the frequency to 1200.00 Hz and adjust R15 for a meter reading of 5.00 volts RMS.

4.3.2.6 PHASE B CALIBRATION

Connect the differential phase meter to terminal 12 (phase B output), terminal 10 (phase A output) and ground. Adjust R34 for a reading of 120 degrees with phase B lagging phase A.

Connect the multimeter to the phase B output, terminals 11 and 12 of TB1. Adjust R17 for a meter reading of 5.00 volts RMS.

4.3.2.7 AUTOMATIC FREQUENCY CONTROL CHECK AND ADJUSTMENT

Rotate the MANUAL FREQUENCY control counterclockwise to display 1176.60 Hz. Place the FREQ SEL switch in the AUTO position. Verify that the frequency displayed increases to and stops at 1200.00 Hz in approximately 60 seconds.

Repeat the foregoing with the RATE switch set at 0.01 HZ/SEC and the frequency set manually to 1199.40 Hz. The time to reach the preset limit should remain at 60 seconds. Change the value of C36, if necessary, if the time required to reach termination varies more than 10 seconds from the specified 60 seconds.

(INTENTIONALLY LEFT BLANK)

SECTION V -- MAINTENANCE

5.1 GENERAL

This section of the manual contains information to assist in troubleshooting the Model 836T Precision Oscillator using "logic tree" types of troubleshooting charts. A review of the Theory of Operation contained in Section III and the Adjustment Procedures of Section IV is recommended prior to attempting to troubleshoot the unit. The technician will then have a good understanding of the circuit operation which will further assist in the troubleshooting task.

5.2 REQUIRED TEST EQUIPMENT

The test equipment required to perform the tests outlined in this section are listed in Table 5-1.

Table 5-1. Required Test Equipment.

Digital Multimeter -- California Instruments Model DMM-53 or equivalent.
Frequency Counter with 3 MHz capability -- Phillips PM6622/02 or equivalent.
Oscilloscope -- Tektronix Model 7000 with 7553 time base and 7A18 amplifier, or equivalent.
Distortion Analyzer -- Hewlett Packard 333A or equivalent.
Differential Phase Meter -- Dranetz 305 with PA3001 plug-in or equivalent.

5.3 POWER SUPPLY CHECK

Refer to paragraph 4.3.1 in Section IV. Perform the power supply adjustment checks of that paragraph before proceeding to the "logic tree" troubleshooting charts.

5.4 TROUBLESHOOTING CHARTS

Several troubleshooting charts are included in this section as Figures 5-1, 5-2, 5-3, 5-4 and 5-5. It is suggested that troubleshooting begin with the tests of Figure 5-1. The termination of any "arm" therein provides direction on what areas to troubleshoot or directs attention to another chart covering a specific area. If experience and the symptoms suggest that the problem lies in an area covered by one of the other charts, the chart of Figure 5-1 may be by-passed.

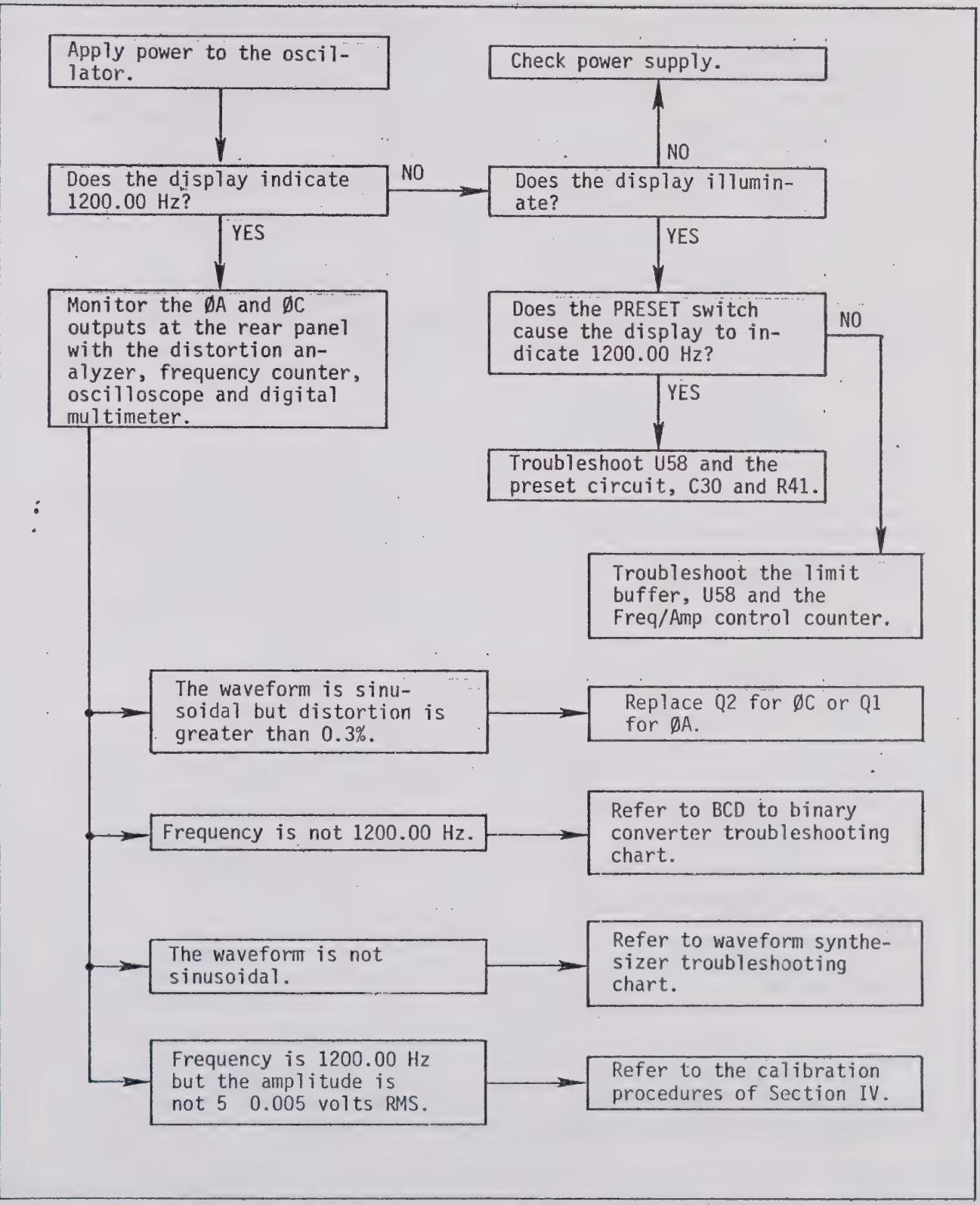

Apply power to the oscillator.
Does the display indicate 1200.00 Hz?
NO
YES
Monitor the ØA and ØC outputs at the rear panel with the distortion analyzer, frequency counter, oscilloscope and digital multimeter.
Check power supply.
NO
Does the display illuminate?
YES
Does the PRESET switch cause the display to indicate 1200.00 Hz?
NO
YES
Troubleshoot U58 and the preset circuit, C30 and R41.
Troubleshoot the limit buffer, U58 and the Freq/Amp control counter.
The waveform is sinusoidal but distortion is greater than 0.3%.
Replace Q2 for ØC or Q1 for ØA.
Frequency is not 1200.00 Hz.
Refer to BCD to binary converter troubleshooting chart.
The waveform is not sinusoidal.
Refer to waveform synthesizer troubleshooting chart.
Frequency is 1200.00 Hz but the amplitude is not 5 0.005 volts RMS.
Refer to the calibration procedures of Section IV.

Figure 5-1. Troubleshooting Chart, Main System.

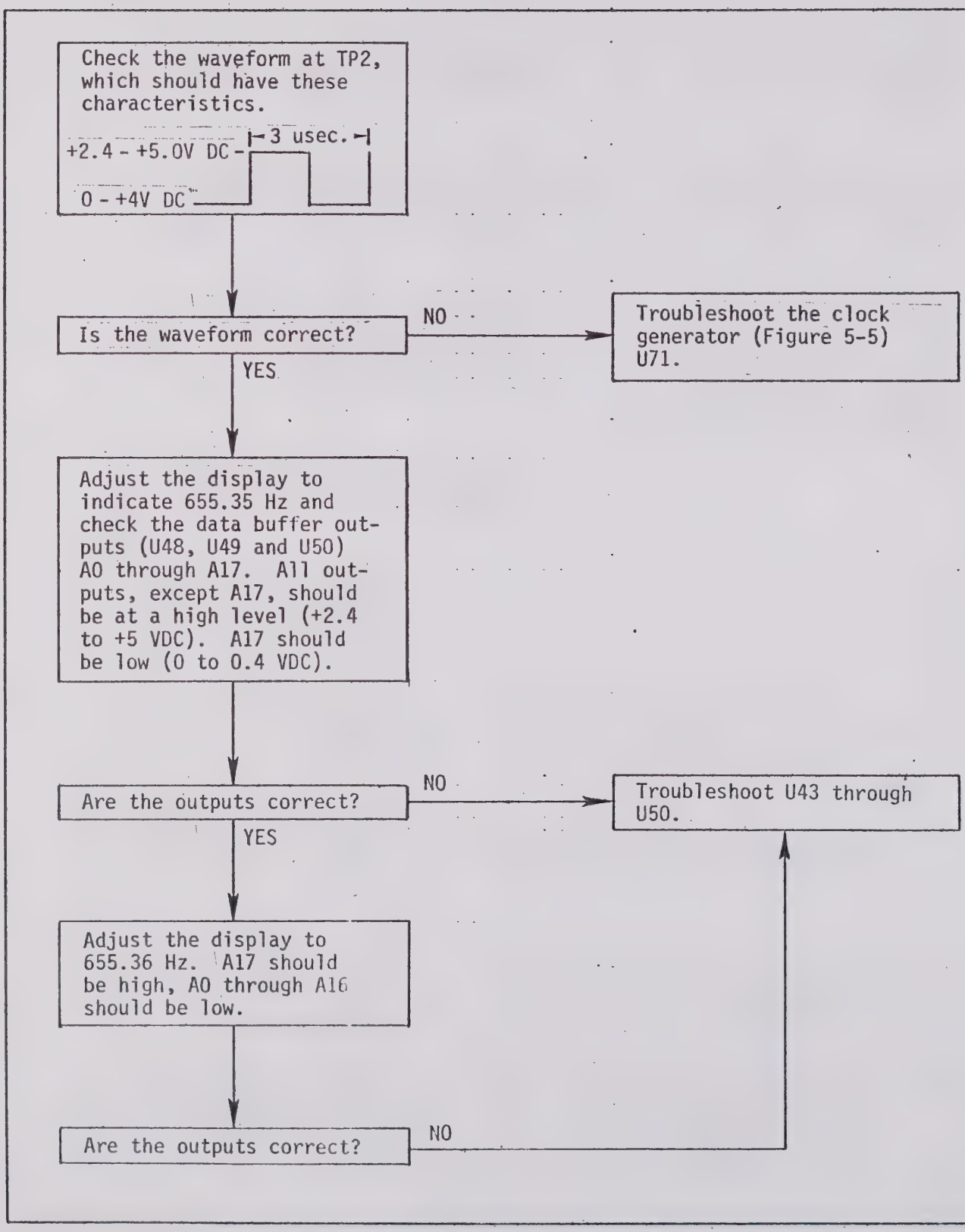

Check the waveform at TP2, which should have these characteristics.
+2.4 - +5.0V DC
3 usec.
0 - +4V DC
Is the waveform correct?
NO
Troubleshoot the clock generator (Figure 5-5) U71.
YES
Adjust the display to indicate 655.35 Hz and check the data buffer outputs (U48, U49 and U50) A0 through A17. All outputs, except A17, should be at a high level (+2.4 to +5 VDC). A17 should be low (0 to 0.4 VDC).
Are the outputs correct?
NO
Troubleshoot U43 through U50.
YES
Adjust the display to 655.36 Hz. A17 should be high, A0 through A16 should be low.
Are the outputs correct?
NO

Figure 5-2. Troubleshooting Chart, BCD to Binary Converter.

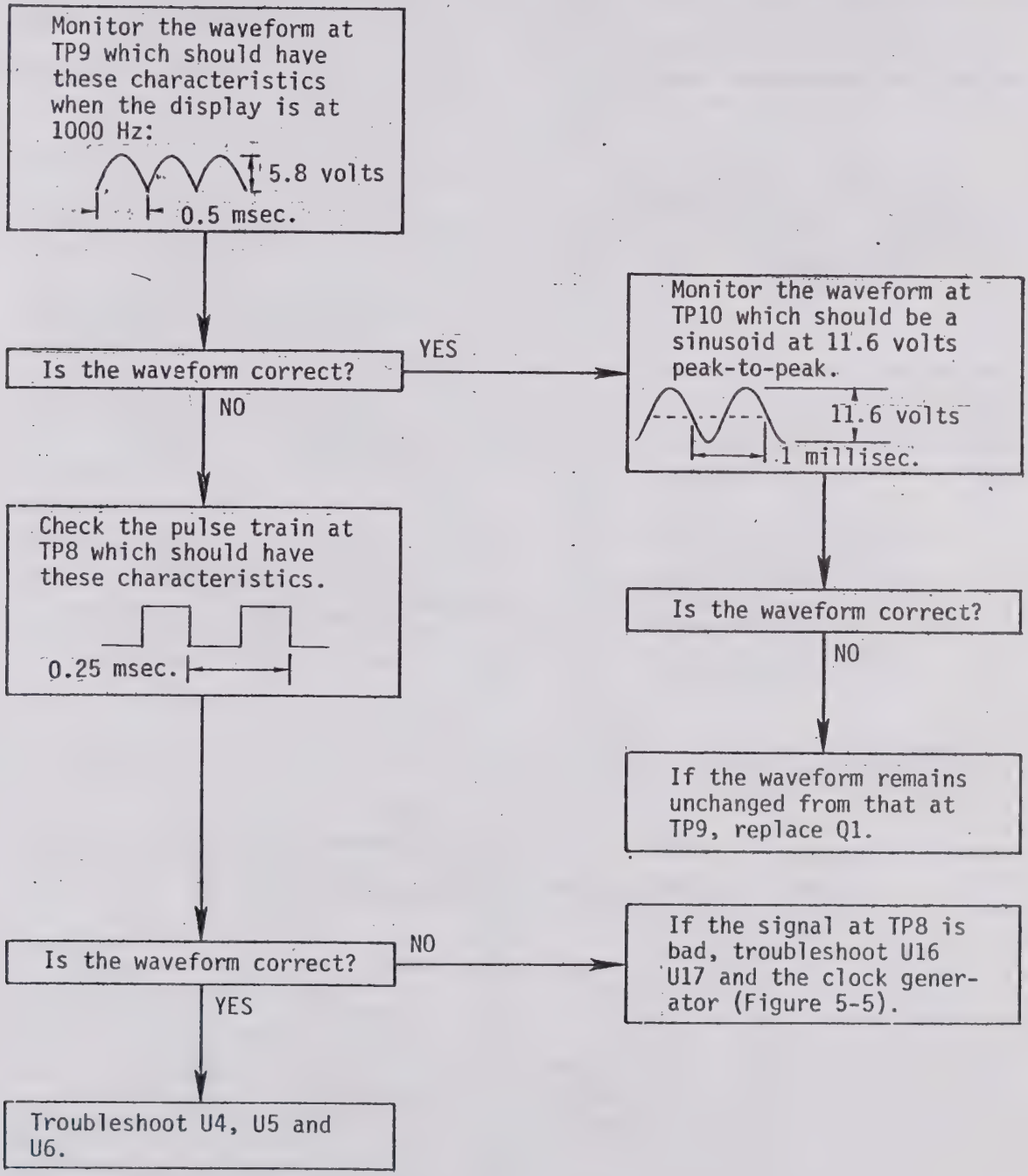

Monitor the waveform at TP9 which should have these characteristics when the display is at 1000 Hz:
5.8 volts
0.5 msec.
Is the waveform correct?
YES
NO
Monitor the waveform at TP10 which should be a sinusoid at 11.6 volts peak-to-peak.
11.6 volts
1 millisec.
Is the waveform correct?
NO
If the waveform remains unchanged from that at TP9, replace Q1.
Check the pulse train at TP8 which should have these characteristics.
0.25 msec.
Is the waveform correct?
NO
YES
If the signal at TP8 is bad, troubleshoot U16 U17 and the clock generator (Figure 5-5).
Troubleshoot U4, U5 and U6.

Figure 5-3. Troubleshooting Chart, Waveform Synthesizer, Phase A.

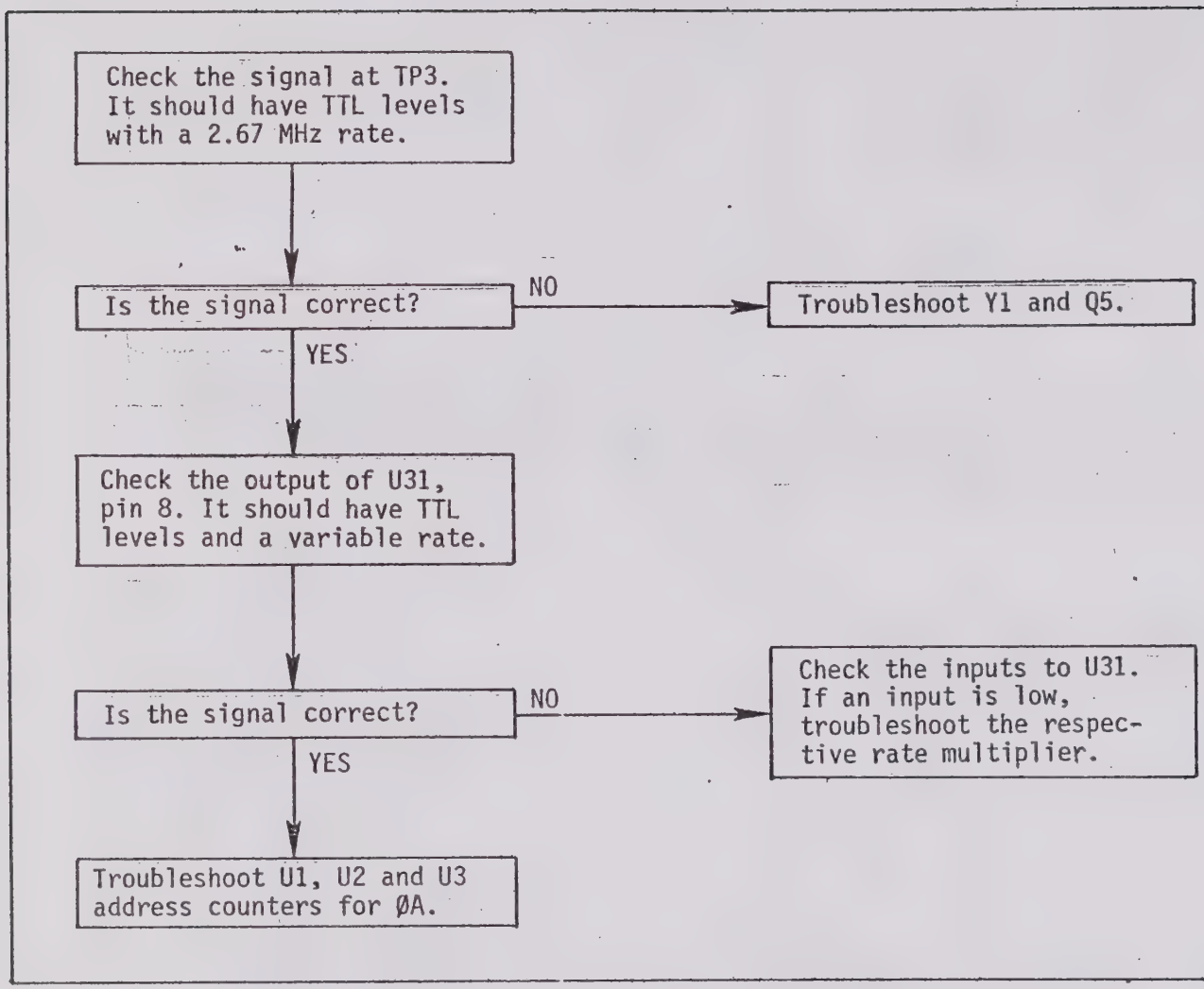

Check the signal at TP3. It should have TTL levels with a 2.67 MHz rate.
Is the signal correct?
NO
Troubleshoot Y1 and Q5.
YES
Check the output of U31, pin 8. It should have TTL levels and a variable rate.
Is the signal correct?
NO
Check the inputs to U31. If an input is low, troubleshoot the respective rate multiplier.
YES
Troubleshoot U1, U2 and U3 address counters for ØA.

Figure 5-4. Troubleshooting Chart, Clock Generator.

POWER-ONE, Inc.
531 DAWSON DRIVE
CAMARILLO, CALIF. 93010
(805) 484-2806

APPLICATION DATA
Including:

1. Schematic
2. Parts List
3. Specification
4. Outling & Mounting Dwg.
5. General User Information

MODEL

HTAA-16W

SPECIFICATIONS:

AC Input: 115/230 VAC ± 10% 47-440 Hz (Derate current 10% for 50 Hz operation)
Input Fusing: See Table
DC Output: 5 VDC @ 2A/OVP @ 6.2 ± .4 VDC
+9-15V @ .4A
-9-15V @ .2A
-or-
-5-10V @ .2A*
Line Regulation: ±.05% for a 10% input change
Load Regulation: ±.05% for a 50% load change
Output Ripple: 3 mv Pk-Pk + .02%
Transient Response: 30μ sec for 50% load change
Overload & Short Circuit Protection: Automatic current limit/foldback
Temperature Coeficient: ±.03%/°C maximum
Cooling: Units are full rated to 50°C in free air, must be derated or fan cocled when mounted in confined area
Temperature Rating: 0-50°C, full rated, derate linearly to 40% at 70°C
Efficiency: 47% at nominal input, full load on output
Weight: 2 lbs.
Vibration: Per Mil-Std-810B, Method 514, Proc. I, Curve AB (to 50 Hz)
Shock: Per Mil-Std-810B Method 516, Proc. V

* This may be accomplished by jumpering E_1 to E_2 and re-adjusting the ouput voltage pot.

AC CONNECTION & FUSE TABLE			
For Use At	Primary Fuse At	Connect	Apply Power
115	0.5A	1-3,2-4	1 & 4
230	0.25A	2-3	1 & 4

2 YEAR GUARANTEE

POWER-ONE will repair or replace any power supply of its manufacture that does not perform to published specifications as a result of defective materials or workmanship for a period of 2 years from date of original purchase. No other obligations or liabilities are implied or expressed. Returns must be freight prepaid.

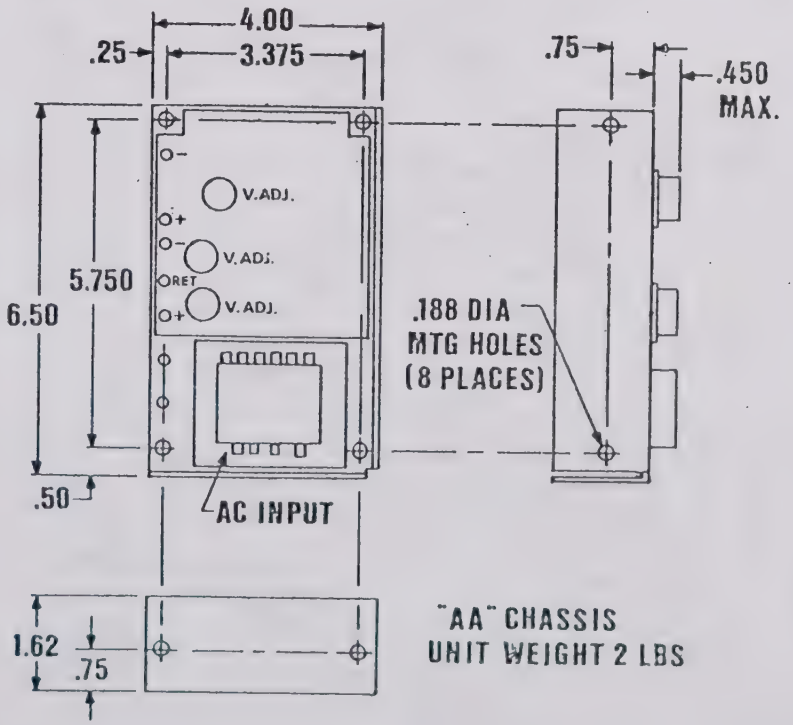


FIGURE 9. Power Supply Specifications.

REF DES	HTAA 16W	STD PN		DESCRIPTION
C1,4	220/16	10-107		CAPACITOR ELECT.
C2	9000/16			
C5,6,8	330/35	10-109		
C11,12	100/35	10-110		ELECT.
C9	200 Pf	10-088		CERAMIC
C3	.01/100			MYLAR
C10	.003/100			CAPACITOR MYLAR
CR1,2	AE3B	10-252		DIODE 3A 100V
CR3,5,6,7,8	AE1C			DIODE 1A 200V
CR4	IN752A	10-006		DIODE ZENER
SCR1	S0303LS3	10-258		SCR 3A
Q1	12500-3	10-261		TRANSISTOR
Q2,4	12500-4	10-260		
Q3	2N2905			
Q5	2N6551	10-249		TRANSISTOR
R3,11,13,15,18	1K	10-365		RESISTOR 1/2W 5% CF
R7	270Ω	10-351		
R5	180Ω	10-347		
R6	2.2K	10-373		
R8,10,14,20	47Ω	10-333		
R16	2.7Ω	10-305		
R24	150Ω	10-345		
R21	1.2K	10-367		1/2W 5% CF
R22	2.32K			1/4W 2% MF
R23	2.8K			1/4W 2% MF
R1	.22	10-079		RESISTOR 2W WW BWH
R12	1.0Ω	10-300		RESISTOR 1/2W 5% CF
R9,17,19	1.5K			POT. 2W WW
U1,2,3	µA723			IC VOLTAGE REGULATOR
T1	12405			TRANSFORMER
PCB	12466			P.C. BOARD
CHASSIS	11091			CHASSIS

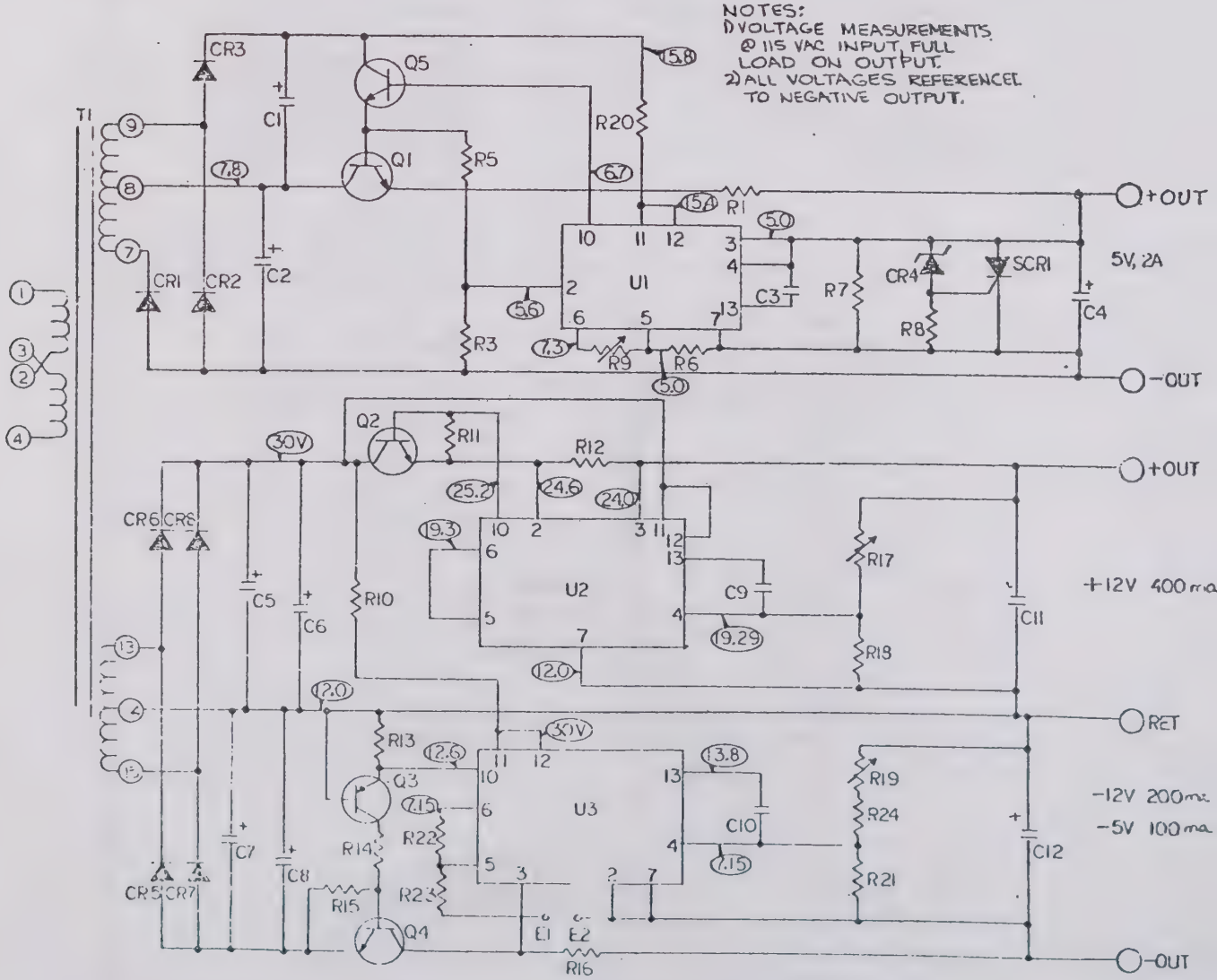


FIGURE 10. Power Supply Schematic and Parts List.

CIRCUIT DIAGRAMS

6.1 GENERAL

This section contains schematic and mechanical diagrams necessary for operation and maintenances of the 836T Precision Oscillator. The schematic diagram illustrates the circuit while the mechanical assemblies indicate the part placement.

6.2 REFERENCE DESIGNATIONS

Partial reference designators are shown on schematics and mechanical drawings. Prefix these reference designators with assembly and/or sub-assembly designation for the complete reference designator. For example:

Assembly/Sub-Assembly	Component	Complete Designation
A1	C30	A1C30
None	T1	T1
A3	CR1	A3CR1

CIRCUIT DIAGRAMS

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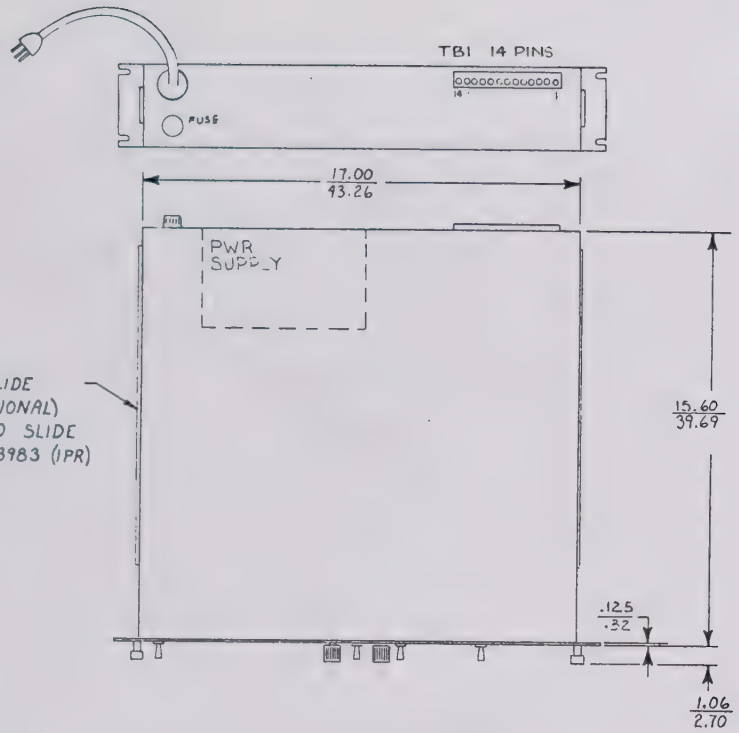
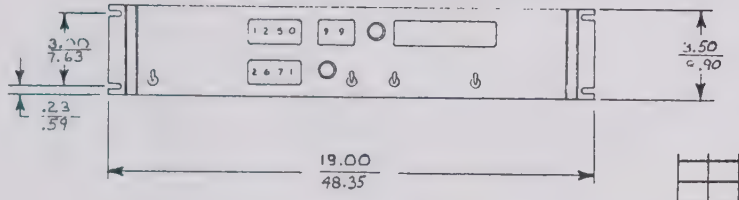
None	T1	T1
A3	CR1	A3CR1

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD
A	ECO	SEE ECO 961-RELEASE			4/16/79	





REQD PER ASSY	ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE

DIM IN INCHES
TOLERANCES
.XXX = .010
.XX = .03
X° = 30'

BREAK ALL SHARP CORNERS & EDGES
MACH SURFACES ✓

DWG SIZE C

TITLE
OUTLINE DRAWING
836T DIGITAL OSCILLATOR

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MODEL 836T
CONTRACT NO.
CODE IDENT 16067

RELEASE	[illegible]	6/1/79	
CHECKER	[illegible]		PURCHASING
DESIGN			PROJ ENGR
DRFTSMN	Robb Merrill	5/7/79	CHF ENGR

DWG NO. C 4836-900 REV A
SCALE NONE SHEET 1 OF 1

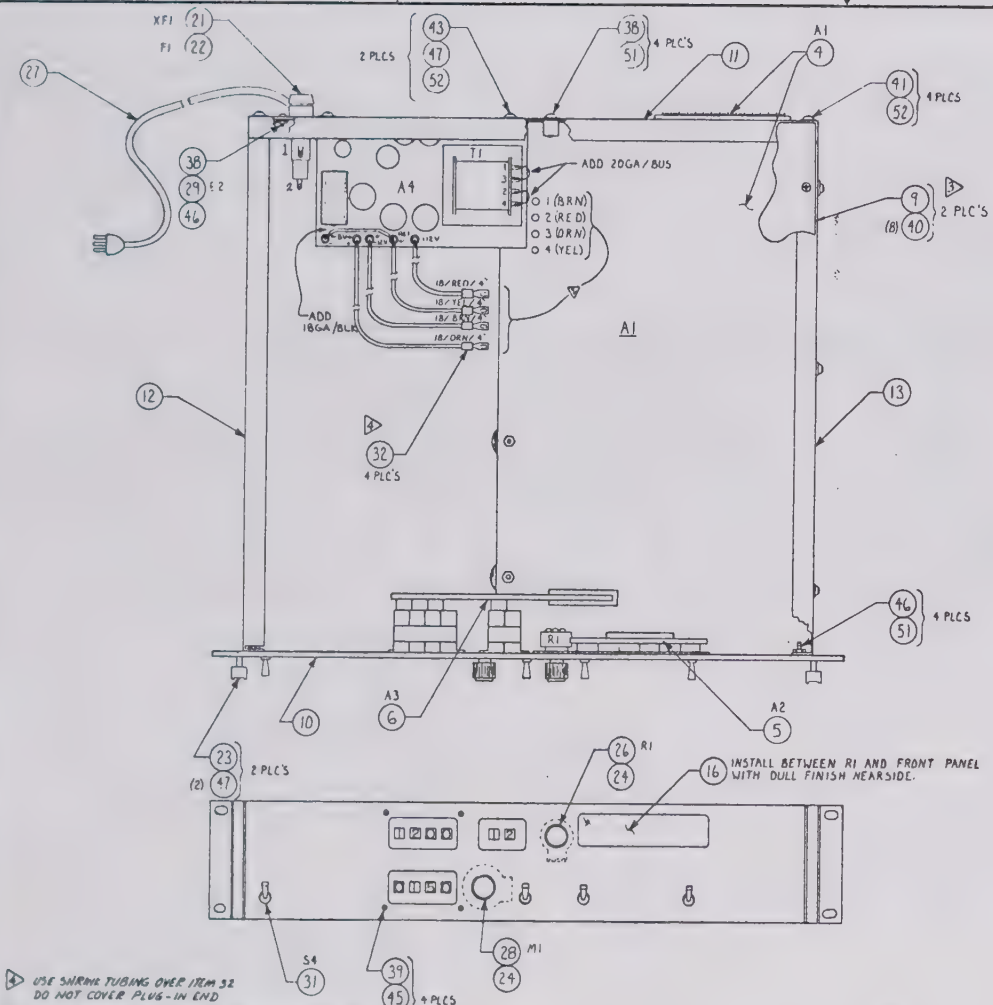
DASH NO.	QTY REQD	NEXT ASSEMBLY	EFF ON	AUTH

2. DIMENSIONS ARE IN INCHES CENTIMETERS
1. FOR ASSY. DWG. SEE D 4836-400.

NOTES: (UNLESS OTHERWISE SPECIFIED)

D4836-900 A

CALICO F-338



WIRING TABLE			
WIRE	FROM	TO	GA/COLOR
1	A1 – 5	M1 – 5	22 / GRN
2	A1 – 6	M1 – 6	22 / BLU
3	A1 – 7	M1 – 7	22 / VIO
4	A1 – 8	M1 – 8	22 / GRY
5	A1 – 9	R1 – 9	22 / WHT
7	A1 – 10	R1 – 10	22 / BLK
8	A1 – 11	R1 – 11	22 / BRN
9	S4 – 2	A4TI – 4	22 / RED
10	S4 – 3	XF1 – 1	22 / BLK
11	P1 – BLK	XF1 – 2	EXSISTING WIRES FROM P1
12	P1 – WHT	A4TI – 1	
13	P1 – GRN	E2 –	
14	A4TI-1	A4TI – 3	20/BUSS
15	A4TI-4	A4TI – 2	20/BUSS
16	A4TI-(-5V)	A4TI-RET	18/BLK
17			
18			

USE SHRINK TUBING OVER ITEM 32 DO NOT COVER PLUG-IN END

REMOVE METAL DUST FROM INSIDE UNIT AFTER THREAD FOR TOP & BOT. COVERS HAS BEEN CUT IN REAR & SIDE PANELS

MATES WITH EXISTING WIRES ON A1 BD. (MATCH COLORS)

1. FOR SCHEMATIC SEE D4836-070 (3 SHEETS)

NOTES: (UNLESS OTHERWISE SPECIFIED)

REVISIONS

REV	AUTH	DESCRIPTION	ZONE	ECP OR	DATE	APPD
		SEE SHEET 1				

D4836-400

ITEM NO	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES	ZONE
REQD PER ASSY	D4836-400-1	PARTS LIST SEE SHEETS 3 & 4					

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X = .1 — BREAK ALL SHARP CORNERS & EDGES MACH SURFACES ✓ — DWG SIZE D

TITLE: UNIT ASSEMBLY DIGITAL OSCILLATOR

MODEL 836T

CALICO — CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

CONTRACT NO. — CODE IDENT 16067

DWG NO D4836-400 — REV A

SCALE NONE — SHEET 2 OF 4

RELEASE: J. Kaya 11/14/79

CHECKED: M. Wester 5/8/79 PURCHASING

DESIGN: D. Mitchell 4-30-79 PROJ ENGR

DRAFTSMAN: A. Candelaria 5-5-79 CHF ENGR

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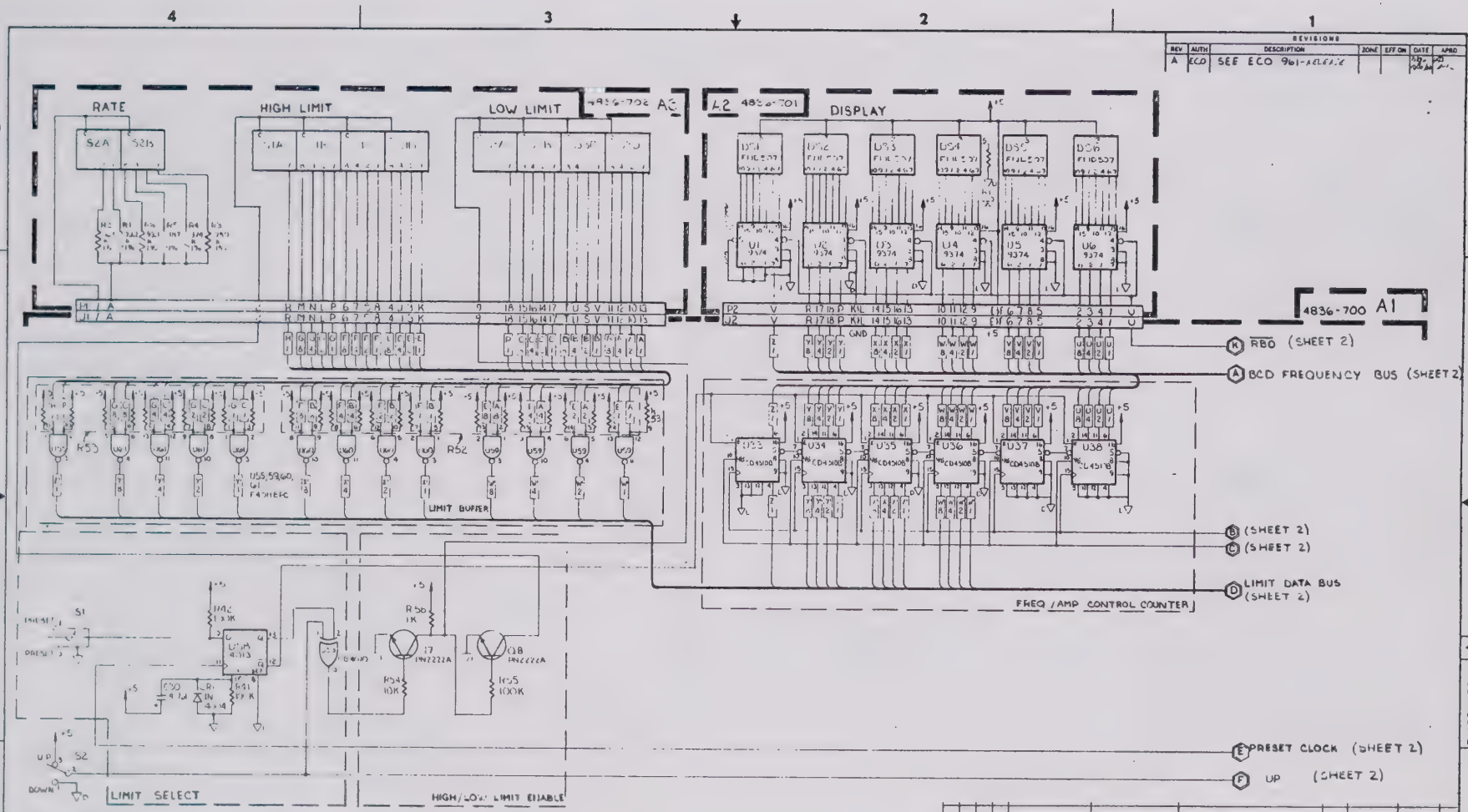

7. ALL WAVEFORMS SHOWN WITH FREQUENCY PROGRAMMED TO 1KHz.
6. (TP) INDICATES TEST POINTS ON A1 BOARD.
5. ALL CAPACITORS IN MICROFARADS.
4. (A) INDICATES TIE POINTS ON A1 BOARD.
3. (X) INDICATES INTERCONNECTIONS BETWEEN SHEET 1 THRU SHEET 3 OF THIS DIAGRAM.
2. FOR UNIT ASSY SEE 4836-400-1.
1. THIS SCHEMATIC (3 SHEETS) REPRESENT A1 P.C.B. 4836-700-1, A2 4836-701, AND A2 P.C.B. 4836-702-1.

NOTES (UNLESS OTHERWISE SPECIFIED)

9. LISTED BELOW ARE LAST COMPONENTS USED ON P.C.B. A1: C37, CR2, V2, Q10, R67, S3, TB1, U72, Y1.
8. ALL RESISTORS ARE ¼W, 5%.

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD
A	ECO	SEE ECO 961-RELEASE				

ITEM NO	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES	ZONE

REQD PER ASSY

DIM IN INCHES TOLERANCES: XXX = .000, XX = .00, X = .0; BREAK ALL SHARP CORNERS & EDGES MACH SURFACES ✓

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DWG SIZE D

TITLE: SCHEMATIC DIAGRAM DIGITAL OSCILLATOR

MODEL 8367

RELEASE

CHECKED

DESIGN

DRAFTSMAN Hubb Barnett 4/11/79

PURCHASING

PROJ ENGR

QAE ENGR

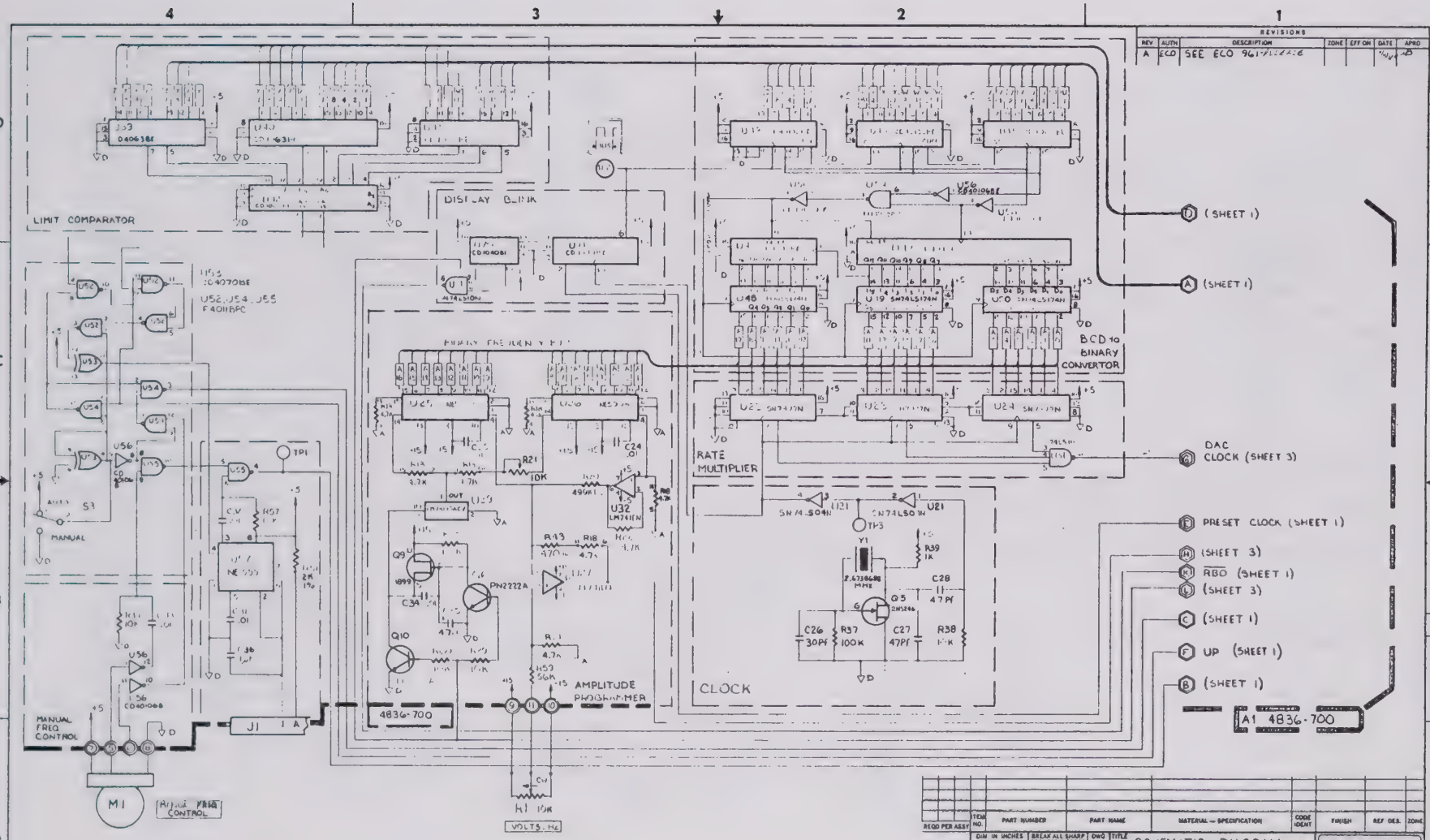
CALICO — CALIFORNIA INSTRUMENTS CORP SAN DIEGO, CALIFORNIA

CONTRACT NO. | CODE IDENT 16067

DWG NO D4836-070 | REV A

SCALE NONE | SHEET 1 OF 3

ORDER NO | QTY REQD | NEXT ASSEMBLY | QTY ON | AUTH



REVISIONS

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRO
A	ECO	SEE ECO 961-[illegible]			[illegible]	

1. ALL WAVEFORMS SHOWN WITH FREQUENCY PROGRAMMED TO 1KHz.
SEE SHEET ONE

NOTES (UNLESS OTHERWISE SPECIFIED)

ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE

REQD PER ASSY

DIM IN INCHES TOLERANCES .XX = .03 .X = .10 ANGLE = 1°

BREAK ALL SHARP CORNERS & EDGES MAX .005" RADIUS

DWG SIZE D

TITLE SCHEMATIC DIAGRAM DIGITAL OSCILLATOR

MODEL 836T

CALICO
CALIFORNIA INSTRUMENTS CORP
SAN DIEGO, CALIFORNIA

CONTRACT NO. | CODE IDENT 16067

DWG NO D4836-070 | REV A

SCALE NONE | SHEET 2 OF 3

RELEASE | CHECKER | DESIGN | DRAFTSMAN PCB PATEL 4/14 | PURCHASING | PROJ ENGR | MFG ENGR

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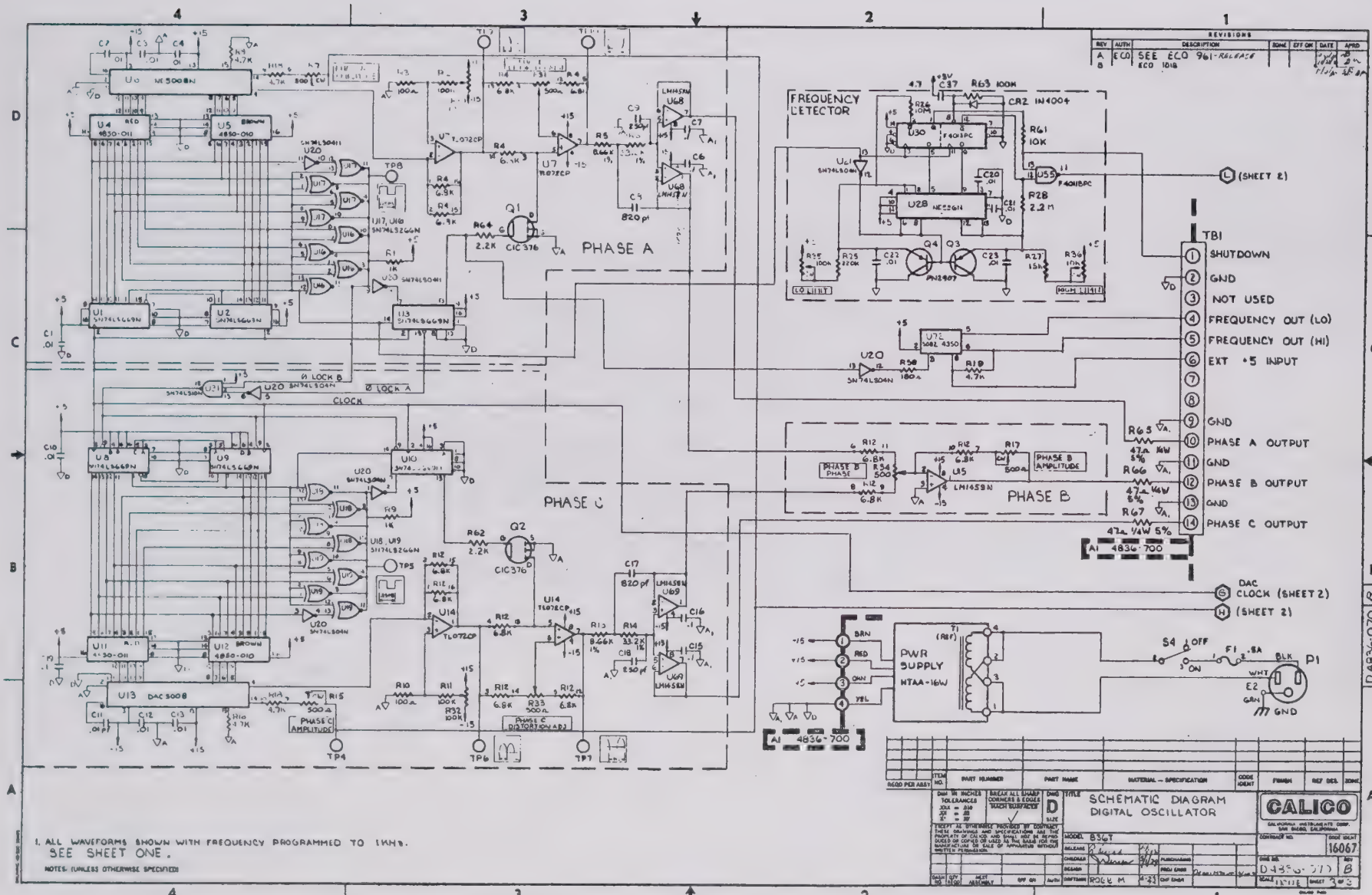
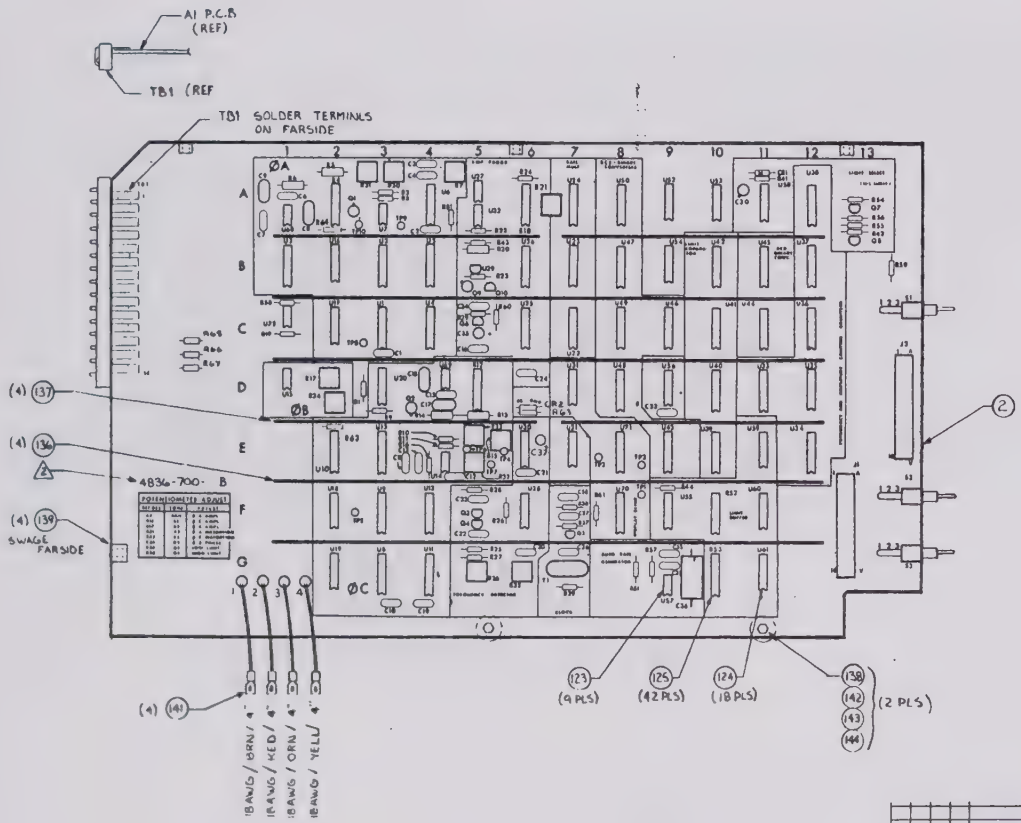
DASH NO | QTY | NEXT ASSY USED | EFF ON | AUTH

D4836-070 A


REVISIONS
REV AUTH DESCRIPTION ZONE CHK OK DATE APPD
A ECO SEE ECO 961-RELEASE
B ECO 1018
FREQUENCY DETECTOR
PHASE A
PHASE B
PHASE C
PHASE B AMPLITUDE
PHASE B PHASE
PHASE C AMPLITUDE
PHASE C DISTORTION ADJ
LO LIMIT
HIGH LIMIT
CLOCK
Ø LOCK A
Ø LOCK B
TB1
1 SHUTDOWN
2 GND
3 NOT USED
4 FREQUENCY OUT (LO)
5 FREQUENCY OUT (HI)
6 EXT +5 INPUT
9 GND
10 PHASE A OUTPUT
11 GND
12 PHASE B OUTPUT
13 GND
14 PHASE C OUTPUT
A1 4836-700
DAC CLOCK (SHEET 2)
(SHEET 2)
PWR SUPPLY WTAA-16W
S4 OFF ON
F1 .8A
P1
GND
SCHEMATIC DIAGRAM
DIGITAL OSCILLATOR
CALICO
MODEL 8367
D 4836-070 B
SHEET 3 OF 3
1. ALL WAVEFORMS SHOWN WITH FREQUENCY PROGRAMMED TO 1KHz.
SEE SHEET ONE.
NOTES: UNLESS OTHERWISE SPECIFIED

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD
		SEE SHT ONE				



ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE
REQD PER ASSY	PL4836-700-1	PARTS LIST	SEE SHEET 4 THRU 7				

DIM IN INCHES
TOLERANCES
XXX = .010
.XX = .05
.X = .1

BREAK ALL SHARP CORNERS & EDGES
.005 MAX RADIUS

SIZE D

TITLE
P.C.B. ASSEMBLY
DIGITAL ANALOG A1

CALICO
CALIFORNIA MICROWAVE CORP
SAN DIEGO, CALIFORNIA

MODEL 8367

CONTRACT NO.

CODE IDENT 16067

DWG NO. D4836-700

REV 8

SCALE 1/1

SHEET 2 OF 7

DASH NO	QTY REQ'D	NEXT HIGHER ASSY	EFF ON	AUTH
-1	1	4836-100-1		

RELEASE
CHECKED
DESIGN
DRAFTSMAN Robb 9/60
PURCHASING
PROJ ENGR
CHF ENGR

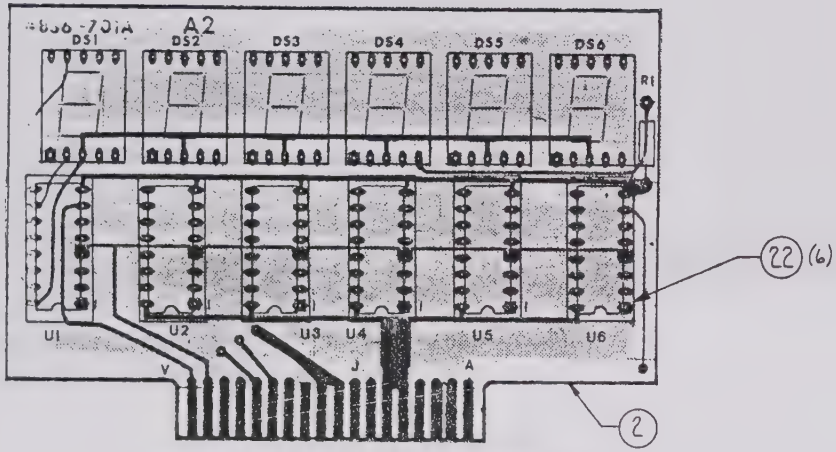
⚠ WHEN ASSEMBLING MARK DASH OF ASSY IN AREA PROVIDED.

1. FOR SCHEMATIC SEE DWG. NO. D4836-070 (3 SHEETS).

NOTES: (UNLESS OTHERWISE SPECIFIED)

D4836-700 B

REVISIONS					
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD



COMPONENTS AND CLAD SHOWN, NEAR SIDE

ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE
1	PL 4836-701-1	PARTS LIST	SEE SHEET 4				

REQD PER ASSY

DIM IN INCHES
TOLERANCES
.XXX = .010
.XX = .03
X° = 30'

BREAK ALL SHARP CORNERS & EDGES
MACH SURFACES ✓

DWG SIZE C

TITLE: DISPLAY P.C.BD. ASSY A2

MODEL 836T

CONTRACT NO.

CODE IDENT 16067

DWG NO. C4836-701 REV B

SCALE 2:1 SHEET 2 OF 4

DASH NO.	QTY REQD	NEXT ASSEMBLY	EFF ON	AUTH
-1	1	4836-400-1		

RELEASE R. Fernandez 4/27/79
CHECKER
DESIGN
DRAFTSMN Rose Merrill 3/16/79
PURCHASING
PROJ ENGR
CHF ENGR

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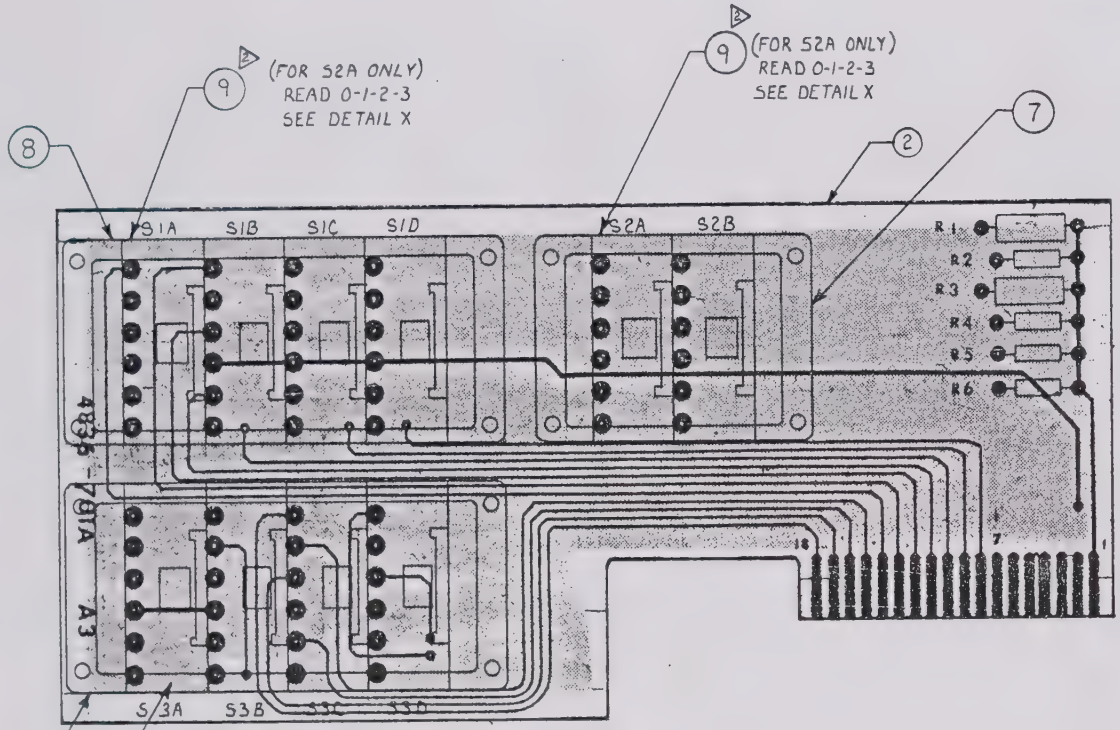
1. FOR SCHEMATIC DWG SEE D4836-070 SHEET 3

NOTES: (UNLESS OTHERWISE SPECIFIED)

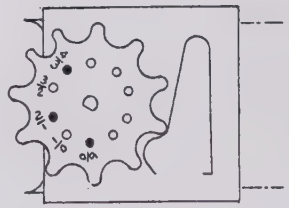
C4836-701 B

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD



-1 PC BOARD ASSY

COMPONENTS & CLAD SHOWN IS NEARSIDE



DETAIL X

1.) FOR S1A AND S3A INSTALL STOPS AT 9/9 AND 3/1

2.) FOR S2A INSTALL STOPS AT 9/9 AND 4/3

C4836-702 B

REQD PER ASSY	ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE
1		PL4836-702-1	PARTS LIST	SEE SHEET 4				

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X° = 30'

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES ✓

DWG SIZE C

TITLE: THUMBWHEEL SWITCH P.C.B. — ASSEMBLY A3

CALIFORNIA INSTRUMENTS a division of AIRCO INDUSTRIES, INC.

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MODEL 3260T OEM

CONTRACT NO.

CODE IDENT 16067

RELEASE				PURCHASING	
CHECKER	Wiener	4/27/76			
DESIGN				PROJ ENGR	Dymtrow 4/29/76
DRAFTSMN	Robb Merrill	4-29		CHF ENGR	

DASH NO.	QTY REQD	NEXT ASSEMBLY	EFF ON	AUTH
-1	1	4836-900-1		

DWG NO. C4836-702 REV B

SCALE 2:1 SHEET 2 OF 4

CALICO F-102

▷ ASSEMBLE S1, S2 & S3 SWITCHES AFTER INSTALLATION OF ITEM 9 (PLASTIC STOPS)

1. FOR SCHEMATIC DWG SEE D4836-070 SHEET 3

NOTES: (UNLESS OTHERWISE SPECIFIED)

REPLACEABLE PARTS

7.1 GENERAL

This section contains ordering information and complete list of replaceable parts. Parts are listed by major assembly in alphanumerical order of their reference designators. Description, manufacturers' part number, manufacturers' code ident number (see Appendix A or list of manufacturers), and CALIFORNIA INSTRUMENTS stock numbers are indicated.

7.2 ORDERING INFORMATION

In order to provide our customers with prompt service on replacement parts, please provide the following information, when applicable, for each part ordered:

a) Model number and serial number of the instrument,

b) CALIFORNIA INSTRUMENTS part number of the sub-assembly where component is located,

c) Component reference designator,

d) Component description,

e) Component manufacturer's number and code ident,

f) CALIFORNIA INSTRUMENTS stock number.

All replacement parts orders should be placed with CALIFORNIA INSTRUMENTS, Division of Norlin Industries, San Diego, California, 92111.

California Instruments

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
	4836-400-1	Digital Oscillator Assy	16067		1
					2
					3
A1	4836-700-1	PCB Main Board Assy	16067		4
A2	4836-701-1	PCB Display Board Assy	16067		5
A3	4836-702-1	PCB Switch Board Assy	16067		6
A4	HTAA-16W	Power Supply	54407	2-50342	7
					8
	4500-208-7	Cover, Top/Bottom	16067	1-10704	9
	4836-200-7	Front Panel	16067	1-10721	10
	4836-201-7	Rear Panel	16067	1-10722	11
	4500-207-7	Side Panel L.H.	16067	1-10702	12
	4500-207-8	Side Panel R.H.	16067	1-10703	13
	4836-204-7	Screen, Fan	16067	1-10719	14
	4836-204-8	Screen, Fan	16067	1-10720	15
	4836-203-7	Display Plex Glass	16067	2-10667	16
					17
					18
					19
B1	8550	Fan	23936	2-41171	20
XF1	345001	Fuse Holder	75915	2-40264	21
F1	AGX-1/2A	Fuse 1/2A 250V	71400	2-40362	22
	13747-A-0832-1B	Handle w/Blk Insert	06540	2-10654	23
	PS-70-2 Black	Knobs	21604	2-40233	24
P1	IN505	Plug	000AK	2-50343	25
R1	B4010-012-1	Pot, Precision 10K1/2W	16067	5-70128	26
	17237	Power Cord	70903	2-50203	27
M1	PC66D-127-5	Shaft Encoder	15686	2-50341	28
E2	1416-6	Solder Lugs	83330	2-50047	29
	SR-5L-1	Strain Relief	28520	2-10480	30
S4	571-1121-0101-011	Switch Toggle	72619	2-40489	31
	5010	Female Quick Terminal	83330		32
					33
					34
					35
					36

MODEL 836T | CALICO P/N 4836-400 | ASSY R.D.

TITLE UNIT ASSEMBLY DIGITAL OSCILLATOR | SHT 3 OF 4

California Instruments

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
					37
	6-32x5/16 LG	Screw PN HD.	81349		38
	4-40x5/16 LG	Screw PN HD	81349		39
	6-32x5/16 LGTypeD	Screw Slf. Tap Pn Hd	81349		40
	8-32x5/16LG typeD	Screw Slf. Tap Pn Hd	81349		41
	8-32x1/2 LG	Screw Flat HD.	81349		42
	8-32x3/8 LG	Screw Pn HD	81349		43
					44
	4-40	Nut, Hex	81349		45
	6-32	Nut, Hex	81349		46
	8-32	Nut, Hex	81349		47
					48
					49
	#4	Washer, Int Str	81349		50
	# 6	Washer, Int Str	81349		51
	#8	Washer, Int Str	81349		52
					53

MODEL 836T | CALICO P/N 4836-400 | ASSY R.D.

TITLE UNIT ASSEMBLY DIGITAL OSCILLATOR | SH. 4 OF 4

California Instruments

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1	4836-700-1	PC Board Assy	16067		1
	4836-700-7	PC Board Mech	16067	1-60309	2
					3
					4
C1, 2, 3, 4, 10, 11, 12, 13, 20, 21, 24, 25, 31, 32, 33, 34					5
	CK103	CAP. .01µf 50V	71590	6-10094	6
					7
C22, 23	C280AE/A10K	CAP. .01µf 250V	80031	6-10929	8
C6, 7, 15, 16, 19					9
	TCA-104z	CAP .1µf 25V	02799	6-11007	10
					11
C36	Z1A105	CAP 1µf 100V	12406	6-10434	12
C30, 35	T362B475MO25AS	CAP 4.7 µf 25V	05397	6-10802	13
C5, 14	CM05E200J03	CAP 20pf 500V	81349	6-10008	14
C26	CM05E300J03	CAP 30pf 500V	81349	6-10263	15
C27, 28	DM15F251K	CAP 47pf 500V	81349	6-10268	16
C9, 18		CAP 250pf 500V	72136	6-10620	17
C8, 17	CM05F821J03	CAP 820pf 500V	81349	6-10050	18
					19
					20
					21
CR1	IN4004	Diode	04713	3-10062	22
					23
					24
V1, 2	H421021-18	Connector 36 Pin	01295	4-10285	25
					26
					27
Q9	U1899E	Transistor, Fet	15818	3-30196	28
Q5	2N5246	Transistor, Fet	16067	3-30245	29
Q6, 7, 8, 10	PN2222A	Transistor,	07263	3-30284	30
Q3, 4	PN2907A	Transistor	07263	3-30285	31
Q1, 2	SD213	Transistor	18324	3-30308	32
					33
					34
R3, 10	RC07GF101J	Res 100Ω 5% 1/4W	81349	5-10029	35
R58	RC07GF181J	Res 180Ω 5% 1/4W	81349	5-10035	36

MODEL 836T | CALICO P/N 4836-700 | ASSY R.D. A1

TITLE Digital Analog P.C. Bd. Assy | SHT 5 OF 7

California Instruments

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
					73
					74
					75
S1	573-1322-0101-100	Switch Toggle	72619	2-40487	76
S2, 3	573-1122-0101-100	Switch Toggle	72619	2-40488	77
					78
TB1	410-Y-14	Terminal Block	75382	2-50336	79
					80
U57	NE555Y	I. C.	18324	3-60026	81
U72	5082-4350	I. C.	28480	3-60073	82
U48, 49, 50	SN74LS174N	I. C.	81349	3-60088	83
U4, 5, 11, 12	82S129N	I. C.	18324	3-60109	84
U31	SN74LS10N	I. C.	07263	3-60143	85
U20, 21	SN74LS04N	I. C.	07263	3-60159	86
U53	CD4070BE	I. C.	18722	3-60163	87
U30, 58	F4013PC	I. C.	07263	3-60197	88
U56	CD40106BE	I. C.	18722	3-60198	89
					90
U52, 54, 55, 59, 60, 61					91
	F4011BPC	I. C.	07263	3-60202	92
					93
U7, 14, 15, 68, 69					94
	TL072CP	I. C.	01295	3-60213	95
					96
U28	NE556N	I. C.	18324	3-60234	97
U29	LM78L10AG2	I. C.	27014	3-60236	98
U27	LM741EN	I. C.	27014	3-60237	99
					100
U1, 2, 3, 8, 9, 10					101
	SN74LS669N	I. C.	01295	3-60238	102
					103
U16 TRU	19				104
	SN74LS266N	I. C.	01295	3-60239	105
					106
U6, 13, 25, 26					107
	NE5008N	I. C.	18324	3-60240	108

MODEL 836T	CALICO P/N 4836-700	ASSY R.D. A1
TITLE Digital Analog P.C. Bd. Assy	SHT 6 OF 7	

California Instruments

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
					109
U22, 23, 24					110
	SN7497N	I. C.	01295	3-60246	111
					112
U33-38					113
	CD4510BE	I. C.	27014	3-60247	114
					115
U39-42					116
	CD4063BE	I. C.	27014	3-60248	117
					118
U43, 44, 45	CD40102BE	I. C.	27014	3-60249	119
					120
U46, 47, 70, 71					121
	CD4040BE	I. C.	27014	3-60250	122
	C85-08-01	I. C. Socket 8 Pin	01295	3-60230	123
	C85-14-01	I. C. Socket 14 Pin	01295	2-30056	124
	C85-16-01	I. C. Socket 16 Pin	01295	2-30057	125
					126
					127
Y1	2.67387MHZ	Crystal .005%. 20pf	000af	2-50340	128
					129
					130
					131
					132
					133
					134
					135
	VL1B-133212	BusBar (Dual 12)	000AL	2-50344	136
	VL1B-133206	BusBar (Dual 6)	000AL	2-50345	137
	2192	Bumper Rubber	83330	2-10154	138
	2039C	Chassis Fastener	83330	2-10670	139
					140
	5014	Terminal, Quick Disc. FML	83330		141
	6-32 x 3/8 LG	Screw Pan HD	81349		142
	6-32	Screw Hex	81349		143
	#6	Washer Int. Str.	81349		144

MODEL	CALICO P/N	ASSY R.D.
836T	4836-700	
TITLE	SHT OF	
Digital Analog P.C. BD. Assy	7 7	A1

California Instruments | CODE IDENT 16067 | PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A2	4836-701-1	DISPLAY P.C.B. ASSY	16067		1
	4836-701-7	P.C.B. MECH.	16067	1-60310	2
					3
					4
DS1 THRU DS6					5
	FND 506-9	DISPLAY, 7BAR NUM.	000AC	2-30073	6
					7
					8
					9
U1 THRU U6					10
	9374	INTERGRATED CIRCUIT	07263	3-60229	11
					12
					13
					14
					15
					16
					17
					18
					19
R1	RC07GF221J	RESISTOR 220Ω 1/4W 5%	81349	5-10037	20
					21
	CA-16S-TSD	I.C. SOCKET 16 PIN	52072	2-30057	22
					23
					24
					25
					26
					27
					28
					29
					30
					31
					32
					33
					34
					35
					36

MODEL	CALICO P/N	ASSY R.D.
836T OSCILLATOR	4836-701	
TITLE	SHT 4 OF 4	
DISPLAY P.C. BOARD ASSY		A2

California Instruments

CODE IDENT 16067

PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A3	4836-702-1	THUMBWHEEL P.C.BD ASSY	16067		1
	4836-702-7	P.C. BOARD MECH.	16067	1-60311	2
					3
					4
S1 THRU S3					5
	177602GN	SWITCH/THUMBWHEEL, 0-9	97525	2-40482	6
	77SG-2	THUMBWHEEL END PIECE	97525	2-40484	7
	77SG-4	THUMBWHEEL END PIECE	97525	2-40485	8
	1776-SERIES	THUMBWHEEL STOP	97525	2-40486	9
					10
					11
					12
R1	RN60C3652 F	RESISTOR 36.5K 1/8W 1%	81349	5-60516	13
R2	RN55D7322 F	RESISTOR 73.2K 1/8W 1%	81349	5-60753	14
R3	RN60D7503F	RESISTOR 750K 1/4W 1%	81349	5-60166	15
R4	RN55D3743F	RESISTOR 374K 1/8W 1%	81349	5-60755	16
R5	RN55D1873F	RESISTOR 187K 1/8W 1%	81349	5-60754	17
R6	RN55D9312F	RESISTOR 93.1K 1/8W 1%	81349	5-60751	18
					19
					20
					21
					22
					23
					24
					25
					26
					27
					28
					29
					30
					31
					32
					33
					34
					35
					36

MODEL	CALICO P/N	ASSY R.D.
836T OSCILLATOR	4836-702	
TITLE	SHT OF	
THUMBWHEEL SWITCH P.C. BD. ASSY	4 4	A3

APPENDIX A

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbook H4-1 and its latest supplement. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbook.

0000A	ElectriCord	Westfield	PA
0000AA	OK Machine and Tool Corp.	New York	NY
0000AB	Falmat	Harbor City	CA
0000B	Tech. Prod. Sales	Sorrento Valley	CA
0000C	Jackson Bros.	Waddon, Surrey	GB
0000D	Chicago Std. Transformer Co.	Chicago	IL
0000E	Use Code #08289		
0000F	Colvern	Santa Monica	CA
0000G	Use Code #30983		
0000H	Mial of Italy c/o Q.C. Components	Los Angeles	CA
0000I	Use Code #50522		
0000J	Use Code #34333		
0000K	Elma	Schweiz	GE
0000L	Use Code #32293		
0000M	Use Code #16950		
0000N	Use Code #15912		
0000P	Mesa Office Supply	San Diego	CA
0000R	American Handle	Philadelphia	PA
0000S	OPCDA	Edison	NJ
0000T	Use Code #31743		
0000U	Use Code #32293		
0000V	Falmat	Los Angeles	CA
0000W	Miltron Rose Co.	Southampton	PA
0000X	Use Code #52072		
0000Y	Use Code #29990		
0000Z	Timco	Los Angeles	CA
00141	Pic Design Corp.	E. Rockaway	NY
00194	* Walsco Electronics Corporation	Los Angeles	CA
00544	Metal-Cal Div., Avery Prod. Corp.	Inglewood	CA
00656	Aerovox Corporation	New Bedford	MA
00779	AMP, Inc.	Harrisburg	PA
00853	Sangamo Electric Company	Pickens	SC
00866	Goe Eng. Co., Inc.	City of Industry	CA
01121	Allen-Bradley Company	Milwaukee	WI
01179	Ajax Magnethermic Corp.	NE Warren	OH
01255	Litton Industries, Inc.	Beverly Hills	CA
01281	T R W Semiconductors, Inc.	Lawndale	CA
*01295	Texas Instruments, Inc.	Dallas	TX
02111	Spectrol Electronics	City of Industry	CA
02114	Ferroxcube Corp.	Saugerties	NY
02335	Fairchild Controls Corp.	Hicksville, LI	NY
02660	Amphenol Corporation	Broadview	IL
02799	Use Code #72136		
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03516	General Electric Company	Somersworth	NH
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Clairex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec. Co.	Hartford	CT
04062	Use Code #72136		
04713	Motorola Semiconductor Prod., Inc.	Phoenix	AZ
04963	3-M	St. Paul	MN
05236	Jonathan Mfg. Co.	Fullerton	CA
05276	Pomona Electronics Co., Inc.	Pomona	CA
05347	Ultronix	Grand Junction	CO
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05820	Wakefield Engineering, Inc.	Wakefield	MA
06046	Dixeon Meter	Grand Junction	CO
06184	Conelco Components	San Bernadino	CA
06223	Kooltronic Fan Company	Princeton	NJ
06229	Electrovert, Incorporated	Mt. Vernon	NY
06383	Pandult Corp.	Tinley Park	IL
06514	Stantron, Wyco Metal Products	N. Hollywood	CA
06540	Amathom Elect. Hardward	New Rochelle	NY
06682	Magnetic Shield Div.	Chicago	IL
06776	Robinson, Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07088	Kelvin Electric Company	Van Nuys	CA
07115	Use Code #14674		
07256	Silicon Transistor Corp.	Garden City	NY
07263	Fairchild Camera and Instr. Corp.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Unitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co. Div. of Allied Prod. Corp.	New Haven	CT
07713	Sperry Rand Corporation	Norwalk	CT
07716	I R C Incorporated	Burrington	IA
07910	Continental Devices	Hawthorne	CA
08065	Accurate Rubber and Plastics Co.	San Diego	CA
08261	Spectra Strip	Garden Grove	CA
08289	Blinn-Delbert Co., Inc.	Pomona	CA
08594	Eimac Div. of Varian Associates	Salt Lake	UT
08718	Use Code #71468		
08730	Vemaline Products Co.	Franklin Lakes	NJ
09026	Babcock Electronics Corp.	Costa Mesa	CA
09145	Atohm, Technical Industries, Inc.	Burbank	CA
09353	C and K Components, Inc.	Newton	MA
11432	Diamond Metal Sales	Gardena	CA
11815	Cherry Rivet Div., Townsend Co.	Santa Ana	CA
12020	Ovenaire, Incorporated	Charlottesville	VA
12143	Bendix Corporation	Santa Ana	CA
12405	Hycol Corporation	El Monte	CA
12406	Elpac, Incorporated	Fullerton	CA
12463	Omtronics Mfg., Incorporated	Omaha	NE
12673	Wesco Electrical Co.	Greenfield	MA
12697	Clarostat Mfg. Co., Incorporated	Dover	NH
13103	Thermalloy Company	Dallas	TX
13454	Texas Crystals	River Grove	IL
13571	Electronic Research	Overland Park	KS
13919	Burr-Brown Research Corp.	Tucson	AS
14099	Semtech Corporation	Newbury Park	CA
14193	Cal-R Inc.	Santa Monica	CA
14604	Elmwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14674	Corning Glass Works	Corning	NY
14726	Hollingsworth Co.	Phoenixville	PA
14752	Electro Cube, Incorporated	San Gabriel	CA
14907	Cramer Div. of Conrac	Old Saybrook	CT
15112	Electra Scientific Corporation	Fullerton	CA
15636	Elec-trol	Northridge	CA
15801	Fenwall Electronics	Framingham	MA
15818	Ameico Teledyne, Incorporated	Mt. View	CA
15909	Use Code #17870		
15912	Ansley	Los Angeles	CA
16067	California Instruments Company	San Diego	CA
16758	Delco Radio Div., General Motors	Kokomo	IN
16795	Bristol Electronics Inc.	Bedford	MA
16902	Simpson Instruments, Inc.	Escondido	CA
16950	Precision Dynamics Corp.	Burbank	CA
16956	Dennison	Framingham	MS
17745	Angstrohm Precision, Inc.	Van Nuys	CA
17838	Mektron, California General, Inc.	Chula Vista	CA
17856	Siliconix	Santa Clara	CA
17870	Daven Div., Thomas A. Edison	Manchester	NH
18076	Umpco	City of Industry	CA
18121	Wilshire Foam Products, Inc.	Gardena	CA
18178	Vactec Inc.	Maryland Heights	MO
18324	Signatics	Sunnyvale	CA
18612	Vishay Instruments Inc.	Malvern	PA
18677	Scambo Mfg. Co.	Monterey Park	CA
18702	Ducommun Metals and Supply Co.	Los Angeles	CA
18722	R C A	Mountaintop	PA
19080	The Robinson Company	Hawthorne	CA
19781	Potter Company	Sun Valley	CA
20857	South Bay Cable Corp.	Gardena	CA
21270	Behr-Manning	Watervliet	NY
21604	Buckeye Stamping Company	Columbus	OH
22045	Jordan Elect.	Van Nuys	CA
22599	Elastic Stop Nut Corporation	Van Nuys	CA
23039	Deccofelt Products Company	Glendora	CA
23050	Product Components Corp.	Hastings-on-Hudson	NY
23095	Astec Electronics In.	Anaheim	CA
23783	British Radio Electric Ltd.	Washington	DC
23936	Pamotor, Incorporated	San Francisco	CA
24011	E C C	Burlington	MA
24655	General Radio	Concord	MA
24796	Parelco Inc.	Paramount	CA
24931	Specialty Connector Co., Inc.	Indianapolis	IN
25403	Amperex (Diodes)	Slatersville	RI
25684	Victoreen Instrument Co., Inc.	Oak Lawn	IL
25790	Daburn Electronics and Cable Corp.	New York	NY
*01963	Cherry Electronical Prod. Corp.	Waukegan	IL

26528	Lamcor Incorporated	Anaheim	CA
26533	Use Code #98176		
26806	American Zettler Inc.	Costa Mesa	CA
27014	National Semi-Conductor Corp.	Santa Clara	CA
27191	Cutler-Hammer, Inc.	Milwaukee	WI
27264	Molex	Downers Grove	IL
27556	IMB Electronic Products	Santa Fe Springs	CA
27683	Varo, Incorporated	St. Garland	TX
27832	Hughes Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
*28520	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
30066	I-T-E Circuit Breaker Co.	Philadelphia	PA
30817	Instrument Specialities Co.	Little Falls	NJ
30897	Dorrana Co.	Sylmar	CA
30983	Electra/Midland (Mepco/Electra)	San Diego	CA
31743	Elpower	Santa Ana	CA
31951	Tririge Inc.	Pittsburgh	PA
32293	Interail	Cupertino	CA
34333	Silicon General	Westminister	CA
34649	Intel Corp.	Santa Clara	CA
35929	Constanta	Quebec	CN
42190	Muter Company	Chicago	IL
44655	Ohmite Manufacturing Company	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
49956	Raytheon Co.	Lexington	MA
50522	Monsanto, Electronic Special Products	Cupertino	CA
50558	Electronic Concepts Inc.	Eatontown	NJ
51705	ICO/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
53209	W. H. Brady Co.	Milwaukee	WI
56289	Sprague Electric Company	North Adams	MA
57771	Stimson	Bayport	NY
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
60741	Triplett Electrical Instrument Co.	Bluffton	OH
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71002	Birnbach Radio Company, Inc.	New York	NY
71218	Bud Radio	Willoughby	OH
71279	Cambridge Thermionic Corp.	Cambridge	MA
71400	Bussman Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71450	CTS Corporation	Elkhart	IN
71468	ITT Cannon Electric Inc.	Los Angeles	CA
71590	Centralab Div. Globe-Union, Inc.	Milwaukee	WI
71707	Coto-Coil	Providence	RI
71744	Chicago Miniature Lampworks	Chicago	IL
71785	Cinch Manufacturing Company	Chicago	IL
72136	Elmenco (Electro Motive)	Willimantic	CT
72259	Nytronics, Incorporated	Pelham Manor	NY
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72982	Erie Technological Products, Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73445	Amperex (Capacitors)	Long Island	NY
73559	Carling Electric, Inc.	West Hartford	CT
73734	Federal Screw Products, Inc.	Chicago	IL
73899	J F D Electronics Company	Brooklyn	NY
73949	Guardian Electric Mfg. Co.	Chicago	IL
73957	Groov-Pin Corporation	Ridgefield	NJ
74193	Heinemann Electric Company	Trenton	NJ
74276	Signalite, Incorporated	Neptune	NJ
74542	Hoyt Electrical Instrument Works	Penacook	NH
74545	Harvey Hubbel, Inc.	Bridgeport	CT
74970	E. F. Johnson Company	Waseca	MN
75382	Kulka Electric Corporation	Mt. Vernon	NY
75915	Littlefuse, Incorporated	Des Plaines	IL
75987	Use Code #95987		
76055	Mallory Controls	Frankfort	IN
76348	Miller Products Company	New York	NY
76385	Minor Rubber Co.	Bloomfield	NJ
76493	J. W. Miller Company	Los Angeles	CA
76854	Oak Manufacturing Company	Crystal Lake	IL
77342	Potter and Brumfield Div., Amer. Machine and Foundry Company	E. Princeton	IN
77638	General Instruments	Brooklyn	NY
77969	Rubber Craft Corp. of California	Torrance	CA
78189	Shakeproof Div., Illoms Tool Works	Chicago	IL
78299	Struthers-Dunn, Incorporated	Pitman	NJ
78488	Stackpole Carbon Company	St. Marys	PA
78526	Stanwyck Winding Company, Inc.	Newburgh	NY
78553	Tinnerman Products, Inc.	Cleveland	OH
78947	Ucinite Company	Newtonville	MA
79130	Johns-Manville Products Corp.	Chicago	IL
79727	Continental-Wirt Electronics Corp.	Warminister	PA
79963	Zierick Mfg. Corporation	New Rochelle	NY
80031	Mepco/Electra	Morristown	NJ
80122	G. C. Electronics Company	Los Angeles	CA
80223	United Transformer Co.	New York	NY
80294	Bourns, Incorporated	Riverside	CA
80368	Sylvania Electric Products, Inc.	New York	NY
80583	Hammarlund Mfg. Co.	Red Bank	NJ
81073	Grayhill, Incorporated	La Grange	IL
81095	Triad Transformer Corp.	Venice	CA
81312	Winchester Electronics	Oakville	CT
81349	Military Spec., Standardization Division Directorate of Logistic Services DSA		
82104	Standard Grigsby	Aurora	IL
82389	Switchcraft, Incorporated	Chicago	IL
82877	Rotron Manufacturing Co., Inc.	Woodstock	NY
82893	Vector Electronics Inc.	Sylmar	CA
83058	Car Fastener Company	Cambridge	MA
83125	Nytronics Inc. Cap. Division	Darlington	SC
83324	Rosan, Incorporated	Newport Beach	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83594	Burroughs Corporation	Plainfield	NJ
83701	Electronic Devices, Incorporated	Yonkers	NY
83781	Nail, Electronics	Geneva	IL
83827	Resistors Inc.	Chicago	IL
84171	Arco Electronics, Inc.	Great Neck	NY
86684	R C A	Harrison	NJ
86928	Seastrom Mfg. Co.	Glendale	CA
87034	Marco-Oak Industries	Anaheim	CA
88026	Use Code #27191		
88245	Useco Div., Litton Industries	Van Nuys	CA
89536	Fluke	Seattle	WA
90030	USM Corp.	Beverly	MA
90201	Mallory Capacitor Company	Indianapolis	IN
91459	Alcon Metal Prod. Inc.	Chicago	IL
91506	Augat	Attleboro	MA
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91812	Isaco Corporation	Burbank	CA
91833	Keystone Electronics Corp.	New York	NY
91929	Micro Switch Div., Honeywell, Inc.	Freeport	IL
92194	Alpha Wire Corporation	Elizabeth	NJ
92219	Waldom Electronics, Inc.	Chicago	IL
93332	Sylvania Electric Products, Inc.	Woburn	MA
94222	Southco, Incorporated	Lester	PA
95146	Alco Electronics Products	Lawrence	MA
95303	R C A	Cincinnati	OH
95348	Gordos Corp.	Bloomfield	NJ
95416	Use Code #95146		
95987	Weckesser Company, Inc.	Chicago	IL
96682	Geniseo, Incorporated	Compton	CA
96733	San Fernando Electric Mfg. Co.	San Fernando	CA
97525	Electronic Engineering Co.	Santa Ana	CA
97918	Linemaster Switch Corp.	Woodstock	CT
97954	U.S. Components, Incorporated	Bronx	NY
98159	Rubber Teck, Incorporated	Gardena	CA
98278	Microdot, Incorporated (Lerco)	S. Pasadena	CA
98291	Sealectro Corp	Mamaroneck	NY
98376	Zero Mfg. Co. (West)	Burbank	CA
98978	IERC	Burbank	CA
99028	Globe	Gardena	CA
99378	Atleo Corp.	Woburn	MA
99392	STM Corporation	Oakland	CA
99515	Marshall Industries	Monrovia	CA
99517	Vacco Industries	El Monte	CA
99742	Permacel Div., Johnson and Johnson	New Brunswick	NJ
99743	I M C	Maywood	CA
99800	Delevan Electronics Corporation	Aurora	NY
*29990	American Technical Ceramics	Huntington Station	NY

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS, A NORLIN TECHNOLOGY COMPANY warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned to the Company freight prepaid, and when examination reveals that the fault has not occurred because of misuse or abnormal conditions of operation. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, and including the model number and serial number. On receipt of this information, service data or shipping instructions will be furnished. If shipment is indicated, forward the instrument, freight prepaid, to the authorized repair station indicated in the instruction. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. CALIFORNIA INSTRUMENTS will advise the disposition to be made of the equipment and arrange for repair or replacement. Please include model number and serial number when referring to the instrument.

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